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THE CANADIAN ASSOCIATION OF GEOGRAPHERS

THE CANADIAN GEOGRAPHER

LE GÉOGRAPHE CANADIEN

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New Publications — Nouvelles Publications 49

(Nelsons Canadian School Atlas; The Canadian Oxford School Atlas; Glacial Map of Canada).

Published by

THE CANADIAN ASSOCIATION OF GEOGRAPHERS

Publié par

L'ASSOCIATION CANADIENNE DES GÉOGRAPHES

Price — $2.00 — Prix

FRENCH CANADA AND THE OHIO COUNTRY:
a study in early spatial relationship*

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While the Ohio country, the land between the Great Lakes and the Ohio River, was claimed by the French of La Nouvelle France, it was effectively controlled by them only along the Illinois River route and around Detroit. The area of the present states of Ohio and Indiana was largely by-passed and the Ohio River was hardly known. Roughly two hundred years of French rule over a large part of the American continent are alive to-day chiefly in the cultural geography of eastern Canada and in a great number of place names bestowed on lakes, rivers, shore points, bluffs, and settlements by French explorers and traders or by American settlers in memory of earlier French occupancy. There is only scattered visible evidence of the early French influence through field systems and a few houses in the Mississippi Valley. The best example is perhaps the Cahokia Courthouse, believed to have been built in 1737, with perpendicularly set logs and a gallery which surrounds the whole house. It was restored and brought back on to its original stone foundation in Cahokia after it had been shown at the St. Louis Exposition in 1904 and stood for a while at the south end of Jackson Park in Chicago. Another example is Wisconsin's oldest house, the Tank Cottage, built by Joseph Roi before 1800, maintained by the City of Green Bay, Wisconsin. Old French style houses, although deteriorated, are found at Racola along Highway No. 21 in Washington County, Missouri. The preservation of such historical structures, occasionally with regrettable disregard for their original site, is of historical rather than geographic interest.

French Canadians, who stayed on after 1763 or migrated to selected locations farther west, left such geographic expressions of their influence in interior North America as the sign "Bienvenue à St. Boniface" in Manitoba, city plat maps like those of Winnipeg and St. Louis which are partly the result of "additions" based on French field divisions and lot arrangements, locations such as Sheboygan and Manitowoc in Wisconsin, which are the sites of old French trading posts, cultural islands such as the Potosi lead mining district in Washington County, Missouri, and the charm of St. Genevieve in Missouri.[1] French heritage in Louisiana needs no illustrations. French place names and evidences of earlier French occupancy are numerous in Minnesota and Wisconsin, somewhat more localized in Illinois, rarer in Indiana with one famed example, however, Vincennes, and practically absent in Ohio where Duquesne was renamed Pittsburgh. Still, the Ohio Valley was of great significance to the French, and we contend that its neglect may have cost them an empire. The by-passing of the Ohio River by French explorers, the reasons for lack of French control of the Old Northwest, and the results of French neglect represent an important chapter in the political and historical geography of North America which is restated here from the geographical viewpoint, i.e., with emphasis on interareal relationships.

THE ROLE OF LAKE ERIE AND THE OHIO IN FRENCH EXPLORATIONS

Rather than an enumeration of the names of French explorers, their routes and dates of exploration, a short resume of these, as they appear on French contemporary maps, may serve to describe the role of Lake Erie and the Ohio River in the structure of the French Empire.

On Samuel de Champlain's maps, Lake Erie is missing; it was the last of the Great Lakes to be discovered.[2] He shows Grand Lac (Superior), Mer douce (Huron), Lac St. Louis (Ontario), and Lac des Bisrenis (Lake Nipissing), among others. The Ottawa-Nipissing route is laid out in the same detail on Champlain's

* Based on a paper presented at the 53rd Annual Meeting of the Association of American Geographers, Cincinnati, Ohio, 1957. The research was aided by the DeWitt Wallace Macalester Research Fund.

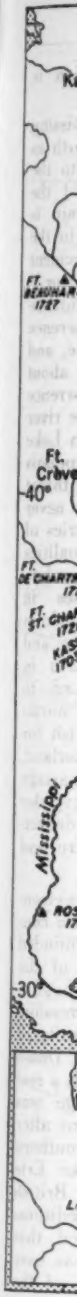
maps as on the Boisseau map of 1643 where an unnamed small lake near "N(ation) du Chats" appears.[3] When Lac du Chat, i.e., Lake Erie, appears on the single map of 1650 by Nicolas Sanson, the latter indicated neither the presence of the Ohio nor the course of any river in that region.[4] Instead, an important French concept, that of "Canada ou Nouvelle France" as a large drainage basin comprising all the land which is drained by the Great Lakes and the St. Lawrence, is cartographically expressed by the symbol of sharply drawn mountain crests, which serve as political boundaries and are emphasized by hand colored lines on the original map.[5] Sanson uses this treatment in his atlas of 1683 for various maps of the American continent. After the turn of the century, in 1703, Delisle represents the Ohio Valley as peripheral to New France and shows the Ohio River as a tributary to the "Ouabache autrement appelée Ohio ou Belle Rivière."[6] Bellin's good maps of 1743 still do not show the bend of the Ohio. The area between Lake Erie and the Ohio is bare of place names, but we are informed that "Ce Canton était habituée par les Eries ou du Nation du Chat qui a été détruits par les Iroquois," and he printed a fateful fact along the southern shore of Lake Erie: "Toute cette coste n'est presque point connue."[7]

A "hardly-known" shoreline could not have functioned as a link in the Great Lakes System of New France. Two historical facts underline this circumstance: the first white man who travelled the length of Lake Erie with canoes, guided by an Iroquois, was Louis Joliet, and he travelled from west to east in 1669 along the northern shore. When Cadillac founded Fort Pontchartrain (Detroit) in 1701, he needed forty-nine days to bring men and supplies, not via Lake Ontario, the Niagara portage and Lake Erie, but via the Ottawa-Nipissing route.

The sketch map by the Jesuit Father Raffeix of Lake Erie and Lake Ontario in 1688 is almost amusing: both lakes have sailing boats. These boats must be ranked with the fabulous fish which also decorated many North American inland waters on the maps of European cartographers, who rarely put a canoe on the lakes and waterways during the canoe age. There was no longer a sailing vessel on Lake Erie or Lake Michigan in 1688. We know of only one boat on Lake Erie before 1763, La Salle's *Griffin*, a 42-45 ton vessel, built above Niagara Falls and launched on Lake Erie in August, 1679. After sailing 240 miles in three days along the north shore of Erie, the boat entered Lake Huron and was sent back from Mackinac with furs to Niagara. It was never heard from again after 1680. Not until seventy-five years after Father Raffeix's sketch did boats built by white men, two schooners, *Huron* and *Michigan*, which brought supplies during Pontiac's war, sail Lake Erie again.

The Ohio was no better known than Lake Erie's southern shore.[8] It is possible that La Salle crossed over to the Ohio from Lake Erie during the winter of 1669-1670.[9] But it is not certain, and La Salle, who is generally credited with having had the vision of a French Empire from the St. Lawrence River to the Gulf of Mexico, still by-passed the Ohio. He and Tonti began the securing of the Illinois route by establishing Forts Crèvecœur and St. Louis on the Illinois and Fort St. Joseph on the St. Joseph River. These became keypoints although they were destroyed shortly after their first establishment. The southern Illinois settlements along the Missisippi, begun at the end of the 17th century, and the development of early Indian trails into trade routes from Detroit via the Calumet region to the Mississippi strengthened the continental pattern of a French crescent which by-passed the Ohio.[10] The Maumee-Wabash route via Vincennes, founded on the Wabash in 1731, was auxiliary to the main actual French crescent which stretched from Quebec to New Orleans with the Illinois settlements as the keystone.[11] Among all the French posts, only the Illinois settlements were fairly self-sufficient. They came to be looked upon as a food surplus region in the eighteenth century, and were expected to become "le grenier de la Louysiane" by Charlevoix in 1721.[12]

The reported dates of the founding of forts do not imply that the forts lasted,



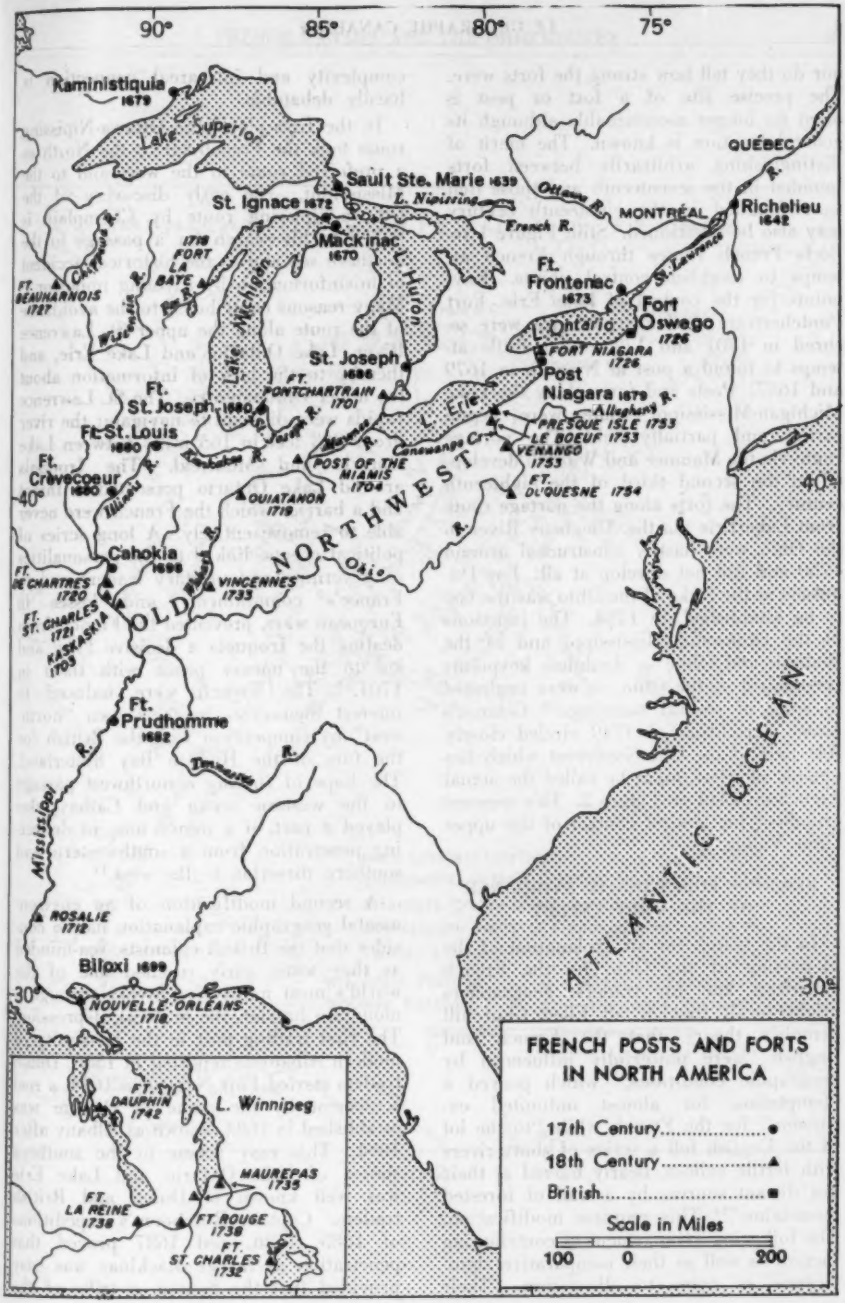

90°
85°
80°
75°
40°
30°
Kaministiquia 1679
Lake Superior
Sault Ste. Marie 1639
L. Nipissing
St. Ignace 1672
Mackinac 1670
1715 FORT LA BAYE
Chippewa R.
Wisconsin R.
Fox R.
FT. BEAUHARNOIS 1727
Lake Michigan
L. Huron
St. Joseph 1686
FT. PONTCHARTRAIN 1701
Ft. St. Joseph 1680
Ft. St. Louis 1680
Ft. Crèvecoeur 1680
Illinois R.
Kankakee R.
Maumee R.
Detroit
L. Erie
Ottawa R.
French R.
QUÉBEC
MONTRÉAL
Richelieu 1642
St. Lawrence R.
Ft. Frontenac 1673
L. Ontario
Fort Oswego 1726
FORT NIAGARA 1726
Post Niagara 1679
Allegheny R.
PRESQUE ISLE 1753
LE BOEUF 1753
VENANGO 1753
FT. DUQUESNE 1754
Conewango Cr.
POST OF THE MIAMIS 1704
OUIATANON 1719
Cahokia 1699
FT. DE CHARTRES 1720
VINCENNES 1733
FT. ST. CHARLES 1721
KASKASKIA 1703
OLD NORTHWEST
Ohio R.
Wabash R.
Ft. Prudhomme 1682
Tennessee R.
Mississippi R.
ROSALIE 1716
Biloxi 1699
NOUVELLE ORLEANS 1718
ATLANTIC OCEAN
FT. ROUGE 1738
FT. LA REINE 1738
MAUREPAS 1735
FT. ST. CHARLES 1732
FT. DAUPHIN 1742
L. Winnipeg
FRENCH POSTS AND FORTS IN NORTH AMERICA
17th Century
18th Century
British
Scale in Miles
100 0 200

Figure 1.

nor do they tell how strong the forts were. The precise site of a fort or post is often no longer ascertainable although its general location is known. The merit of distinguishing arbitrarily between forts founded in the seventeenth and those that were founded in the eighteenth century may also be questioned. Still, Figure 1 reflects French routes through French attemps to establish control points. Keypoints for the control of Lake Erie, Fort Pontchartrain, and Fort Niagara were secured in 1701 and 1726, after futile attemps to found a post at Niagara in 1679 and 1687. Posts and forts along the Lake Michigan-Mississippi route were begun earlier and partially held. The portage route via the Maumee and Wabash developed in the second third of the eighteenth century. The forts along the portage route from Lake Erie via the Allegheny River to the Ohio were hastily constructed around 1750 and did not develop at all. For Duquesne at the forks of the Ohio was the last to be established, in 1754. The junctions of the Ohio and Mississippi and of the Wabash and Ohio — doubtless keypoints for control of the Ohio — were neglected in spite of several warnings.[13] Céloron's famed expedition of 1749 circled closely that part of the Old Northwest which lies outside of what might be called the actual French crescent on Figure 2. This crescent crumbled for lack of control of the upper Ohio Valley.

REASONS FOR FRENCH AVOIDANCE OF THE OHIO VALLEY

In the search for an explanation of the by-passing of the Ohio by the French colonizers and fur traders, geographers might recall first of all Ellen Churchill Semple's theory that the French and English "were powerfully influenced by geographic conditions," which proved a "temptation for almost unlimited expansion" for the French while "to the lot of the English fell a series of short rivers with fertile valleys, nearly barred at their not distant sources by a wall of forested mountains."[14] This requires modification. The following arrangement of contributing factors as well as their comparative significance is open to discussion. Their complexity and interareal connection is hardly debatable.

In the first place, the Ottawa-Nipissing route took the French far to the North as a preferred route to the west and to the Mississippi. The early discovery of the Ottawa-Nipissing route by Champlain is linked to his search for a passage to the northern sea and to the historical accident of misinformation by a young impostor.[15] Many reasons contributed to the avoidance of the route along the upper St. Lawrence River, Lake Ontario, and Lake Erie, and thereby to the lack of information about the upper Ohio country. The St. Lawrence rapids were difficult to navigate; the river drops 223 feet in 165 miles between Lake Ontario and Montreal. The Iroquois around Lake Ontario presented a threat and a barrier which the French were never able to remove entirely. A long series of political events, linked to the personalities of governors and military leaders and to France's commitments and losses in European wars, prevented the French from dealing the Iroquois a decisive blow and led to the uneasy peace with them in 1701.[16] The French were induced to interest themselves in their own "northwest" by competition with the British for the furs of the Hudson Bay hinterland. The hope of finding a northwest passage to the western ocean and Cathay also played a part, if a minor one, in deflecting penetration from a southwestern and southern direction to the west.[17]

A second modification of an environmental geographic explanation has to consider that the British colonists, sea-minded as they were, early reached one of the world's most impressive breaks through a mountain barrier, the Mohawk depression. The first trading post in the proximity of modern Albany is reported in 1540, Dutch traders started Fort Nassau in 1614, a real settlement by the name of Orange was established in 1624, known as Albany after 1664. This easy access to the southern shores of Lake Ontario and Lake Erie was well known to Dutch and British traders. Captain Roseboom's expeditions of 1685, 1686, and 1687 proved that penetration as far as Mackinac was easy provided that the Seneca, a tribe of the

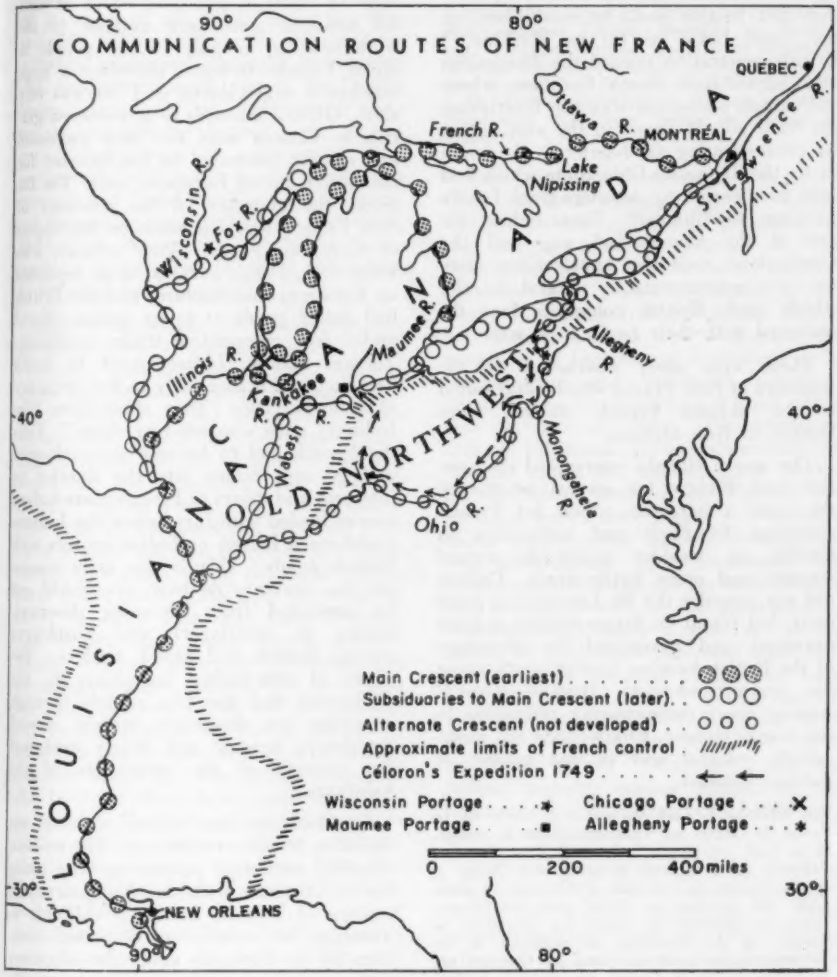

COMMUNICATION ROUTES OF NEW FRANCE
90°
80°
QUÉBEC
CANADA
Ottawa R.
MONTRÉAL
French R.
Lake Nipissing
St. Lawrence R.
Wisconsin R.
Fox R.
Illinois R.
Kankakee R.
Maumee R.
Allegheny R.
Wabash R.
Monongahela R.
Ohio R.
NORTHWEST
OLD
LOUISIANA
40°
30°
NEW ORLEANS
Main Crescent (earliest)
Subsidiaries to Main Crescent (later)
Alternate Crescent (not developed)
Approximate limits of French control
Céloron's Expedition 1749
Wisconsin Portage
Chicago Portage
Maumee Portage
Allegheny Portage
0
200
400 miles

Figure 2

Iroquois League, permitted transit and the French did not — through an accident fortunate for them — intercept.[18] Dr. Daniel Coxe suggested in the early sixteen eighties before the Royal Society in London that British posts be established on the Great Lakes as far as Mackinac.[19] British penetration toward the Mississippi also began from South Carolina, where individuals connected with the flourishing fur trade sought access to the west, either by circumventing the barrier to the south or by the Tennessee-Ohio route which had been used earlier by deserters from Tonti's garrison in Illinois.[20] Even before the era of the Cumberland gap and the Cumberland road the Appalachians were not an insurmountable natural barrier which made British coloniests face the seaboard with their backs to a wall.

There were other weaknesses in the structure of New France which contributed to the ill-fated French crescent from Quebec to New Orleans.

The severe climate interrupted the contact with Europe for several months of the year, a handicap which led French statesmen in Paris and authorities in Canada to consider expansion toward warmer and more fertile areas. Colbert did not consider the St. Lawrence a great asset, but found its frozen estuary a great drawback and recognized the advantage of the British location farther south along the year-around open Hudson River.[21] Among many contemporary references to the severe climate, Charlevoix's are particularly colorful and in one respect of dubious comfort:

"En effet, si le Ciel est serein il soufle de la Partie de l'Ouest un Vent, qui coupe le Visage. Si le Vent tourne au Sud, ou à l'Est, le tems s'adoucit un peu, mais il tombe une Neige si épaisse, qu'on ne voit pas à dix pas en plein midi. S'il survient un Dégel dans les formes, adieu les Chapons de rente, les Quartiers de Boeufs ou de Moutons, les Volailles & les Poissons, qu'on avoit mis dans les Greniers sur la bonne foi de la Gelée; ensorte que, malgré les rigueurs d'un Froid excessif on est encore réduit à souhaiter qu'il ne discontinue pas."[22]

Still, the French did not settle in substantial numbers around Niagara, Detroit, and in the Illinois region where climate was far more pleasant and agriculture more promising. The whole settlement picture had two fundamental weaknesses.

Quantitatively, there were too few settlers. The growth from 3,418 persons in 1666 to 9,000 in 1680, of which at least six hundred men were outlaws in the wilderness, to roughly 80,000 people in all of French America, including a large number of negro slaves, in 1750, was very slow. Official attempts to promote emigration to Canada were not very successful and usually frustrated by the demand for manpower during European wars. The fur trade, the mainstay of the economy of New France, was dependent on the import of European goods. After contact with white men, Indian survival soon depended on European manufacture, and the British had better goods at lower prices offered under free competitive trade conditions. Thomas Nairne, Indian agent in South Carolina, put it succinctly to the Secretary of State in 1708: "They affect them (the Indians) most who sell best cheap." Thus the French had to become supersalesmen and go ever father into the interior to intercept and divert to French posts Indian canoes loaded with furs before the Indians could reach British or Indian traders with British goods. This is the main reason for the coureurs de bois who could not be prevented from becoming deserters, known as interlopers and bushlopers among British and Dutch traders. The drain of able-bodied manpower to the wilderness and the loss of life through accidents on dangerous travels slowed population increase and clearly weakened the strength of the settlements of the habitants.

Qualitatively, the settlements were not suited to frontier conditions. The modern riparian settlement pattern or *rang* along the St. Lawrence, with almost uninterrupted strings of houses, makes it difficult to visualize the isolation of dispersed clearings by the habitants under the seigneury system. Colbert and Louis XIV, frequently warning against further dispersion, insisted that clearings be consolidated, that model villages in compact form like French bourgs be laid out, and that re-settlement be undertaken.[23] Intendant Talon laid out several model villages outside of Quebec

between 1685 and 1762. Some of them have survived to the present with their radial field arrangements like those of Bourg Royal and Charlesbourg. (Figure 2) But the riparian field system "triumphed in spite of all edicts from his Majesty."[24] While this system appeared as a "closer settlement" than the rectangular and single farmstead system of United States origin later on, particularly when it was transplanted farther west, it was not a closed type of settlement in the seventeenth and even in the eighteenth century, and it was hard to defend. Governor Denonville wrote to Paris in November, 1685, that the colony should be re-assembled so as to enable each inhabitant to be aided by his neighbor.[25]

Isolated farmsteads and insufficient fortification were a major reason for the habitant's constant fear of an Iroquois attack and the horror of the Iroquois wars. Pierre Boucher, in his description of the colony, its resources and agriculture, written at the request of Colbert in 1664 wrote of the Iroquois: "Ce mal est grand."[26] This small but well-organized tribe with an estimated two thousand warriors in 1687 was able to block the French toward the south along the Lake Champlain route, to bar them from the southern shore of Lake Erie and Lake Ontario, and to prevent a push toward Albany. Their location gave the Iroquois the advantage of first contact with the Dutch and British, who could sell a gun for two beaver skins at the end of the seventeenth century when it cost five beaver skins in Montreal. The British supported the Iroquois throughout, and were able to establish Fort Chouaguen (Oswego) in 1725 on the southern shore of Lake Ontario in Iroquois country. Thus the English could weaken French control on the only lake where the French had sailing vessels to move suplies. Finally, control over Illinois and the lower Ohio and Wabash country suffered from an additional and peculiar administrative and gegographic uncertainty.

The Crozat patent of 1712, on which the charter for the Compagnie des Indes of 1717 and the royal administration after 1732 were based defined Louisiana as "toutes les Terres par nous possédées & bornées par le nouveau Mexique, & par celles des Anglois de la Caroline, tous les établissements, Ports, Havres, Rivières, & principalement le Port & Havre de l'Isle Dauphine appellées autrefois de Massacre, le Fleuve Saint Louis autrefois appellée Missicipy depuis le port de la Mer jusqu'aux Illinois, ensemble les Rivières saint Philippe autrefois appellée des Missourys, & saint Hierosme autrefois appellée Ovabache avec tous les Pays, Contrées, Lacs dans les Terres & les Rivières qui tombent directement ou indirectement dans cette partie du Fleuve St. Louis."[27]

Two points are important in this definition: the area occupied by the Illinois Indians, which could not be stable in the shifting tribal geography of New France, is used as a basis for a "boundary"; the Ohio is not mentioned at all. Thus, the administration for the Illinois and Wabash country was in dispute; the governors of Canada and Louisiana, de la Gallissionière and Vaudreuil, advanced good reasons for governing it from either side as late as 1748. The boundary between Louisiana and Canada crossed the Wabash about the site of Terre Haute; the Ouiatanon post on the Wabash was administered from Canada. Vincennes, about eighty miles farther downstream, was administered from Louisiana. By tradition and through the fur trade Illinois was tied to Canada, by the geography of the Mississippi valley it was part of the sphere of Louisiana. Secondly, there had been frequent warnings to establish forts along the "Ouabache."[28] Authorities in Louisiana feared the British menace from the east via the Tennessee and other tributaries to the "Ouabache," and the Indian menace, among others, of the Chickesaw who threatened Louisiana's flank from the east.

Here the geographic ignorance must be emphasized. The Ohio appears by many names in French documents.[29] Most writers assumed that the Ohio was a tributary to the Wabash and the stretch of the Ohio from its junction with the Wabash to its mouth was usually called Ouabache. Thus we often cannot know what junction is meant by a fort "at the mouth of the Ouabache," nor can we assume that the region above the junction of the Wabash and Ohio is meant when the Oua-

bache country is mentioned. A passage from Charlevoix illustrates the geographic uncertainty:

"Immédiatement après le grand détour, nous laissâmes à gauche la belle Rivière Ouabache, par laquelle on peut aller jusques ces les Iroquois, quand les eaux sont hautes. Son entrée dans le Micissipi n'a guere moins d'un quart de lieue de large. Il n'est point dans toute la Louysiane de lieu plus propre à mon avis pour un Établissement, que celui-là, ni où il importe davantage d'en avoir un. Tout le pays, qu'arrosent Ouabache, & l'Ohio, qui s'y décharge, est très-fertile; ce sont de vastes Prairies bien arrosées, ou les Boeufs sauvages paissent par milliers. D'ailleurs, la communication avec le Canada n'y est pas moins facile, que par la Rivière des Illinois, & le chemin est beaucoup plus court. Un fort avec une bonne Garrison y tiendrot en bride les Sauvages, surtout les Cheraquis, aujourd'hui la plus nombreuse Nation de ce Continent."[30]

The site of Vincennes, the only trading post and fort of importance, was a compromise between the desire to pull Indians of the Miami tribe away from British influence and to settle them farther south on the Wabash on the one hand and the more desirable site of the Ohio and Wabash junction, forty "lieues" — one hundred miles — downstream, on the other. The post was poorly supplied, suffered from "Indiana's first war,"[31] and its administrative ties with Louisiana were loose. Abandonment of the post and construction of another in a better location, presumably at the mouth of the Wabash, were suggested as late as 1755.

THE RESULTS OF THE ACTUAL FRENCH CRESCENT

The need of controlling Lake Ontario, Fort Niagara, and Lake Erie had been argued earlier. The crucial importance of destroying the British fort on Lake Erie was urged by French contemporaries, notably by De La Gallissionière after he was released from his duties as governor of Canada from 1747 to 1750.[32] His order to Céloron to claim the Ohio Valley for France was poorly executed and his recommendations to develop the Illinois settlements and to resist by force any British attempt to settle along the Ohio were fruitless. But his Memoir is a remarkable document in political geography, and a realistic assessment of the situation of New France at the eve of its downfall.

De La Gallissionière admitted that Canada was always a burden to the French Government. He did not glorify the ability of French Canadians to survive in the wilderness but called it an "accidental" quality. After dealing with the serious loss of Acadia through the treaty of Utrecht in 1713 and of Ile Royale and Louisburg, and after describing the vulnerability of the St. Lawrence settlements, he turned to the interior. He stressed the need for a good fort and settlement on the western shore of Lake Champlain. He considered Fort Oswego illegal since Great Britain did not gain any possession of Iroquois territory through the treaty of Albany with the Iroquois in 1701. He emphasized the need for communication between Canada and the Mississippi via the Ohio, "the most interesting problem in this relation." Discovered and claimed for France by La Salle, the Ohio country "would be full of French settlements had not the governors of Canada been deterred from establishing permanent posts there by the apprehension that a contraband trade between French traders and the British would be the consequence. The Ohio affords the main conveyance from Canada to the River Mississippi."

To de la Gallissionière, Detroit and Niagara were important. He recognized that the Illinois settlements and perhaps they alone would supply food-deficient Louisiana, for their upstream situation would make transportation of bulky goods easy. He wanted more settlers for the core area between Montreal and Quebec, for Niagara and Detroit and the Illinois region. In contrast, such locational features, important in the geography of New France, as the Ottawa-Nipissing route, Fort Mackinac, the Fox-Wisconsin portage, are not mentioned once in the lengthy document.

De La Gallissionière revealed remarkable geographic vision. After more than a century New France had posts and lanes of communication from Quebec on a grand crescent along the Ottawa-Nipissing route and Lake Huron, or along the northern shore of Lakes Ontario and Erie to De-

troit. Three routes focussed on the Illinois settlements, from the Chicago Portage, from Detroit, from the Fox-Wisconsin route. An alternate route that did not exist would have run along the southern shores of Lake Ontario and along the Ohio. No control of any part of what was to become the State of Ohio was seriously attempted. The crescent crumbled first and decisively in the core area where the far-flung lines of communication were late, precarious, and spare when they needed to be early, well-entrenched, and ample. Lack of control of the country between La Belle Rivière and Lac du Chat was the fatal weakness of the political geography of New France.

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MANUFACTURING IN SUBURBAN TORONTO*

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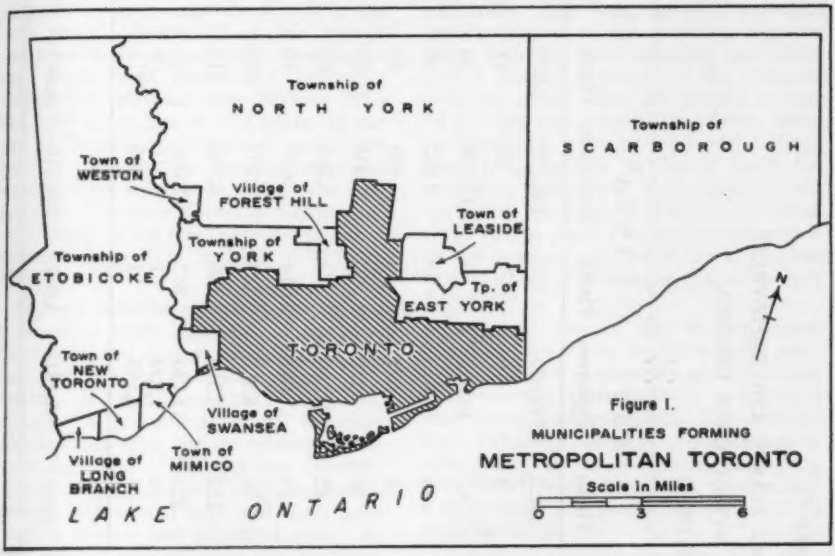


Figure 1.
MUNICIPALITIES FORMING
METROPOLITAN TORONTO

Rapid economic development in Canada since World War II has brought about a considerable expansion of industry in Metropolitan Toronto. In particular, the suburbs have experienced a large growth, partly as a result of the location of new industries, and in part because of the migration of industries from the central city. The purpose of the paper is to identify and analyse the factors which determine the location of manufacturing plants in suburban Toronto.

Metropolitan Toronto, having a population of almost one and a half million, is an administrative unit comprising thirteen municipalities of which the city of Toronto is the largest (see Figure 1). Figure 2 shows the limits of urban growth in the Metropolitan area in 1945 and 1956. Expansion has taken place mainly, but not entirely, in five suburban townships: Scarborough, East York, North York, York and Etobicoke. For the purposes of statistical comparison, these five units may be considered the post-war or new suburbs, although a small amount of urban growth had occurred within them before World War II. Surrounding the city of Toronto are the remaining municipalities of the Metropolitan area. In this paper they are referred to as the old suburbs and they may be grouped into two broad categories: pre-war suburbs such as Leaside, and old towns, like Mimico and Swansea which have been engulfed by the expanding Toronto conurbation.

Table 1 summarizes the development of manufacturing in the different municipalities. In the period 1945 to 1950, manufacturing employment in the city of Toronto increased from 146,355 to 160,063, while it declined from 32,736 to 27,160 in the twelve other municipalities. The closing of war industries, in part, accounts for this decline, especially in Scarborough. In 1950 a new trend set in and manufacturing employment in the city of Toronto began to decline, reaching 134,325 in 1955, a drop of over 25,000

* Presented at the Eighth Annual Meeting of the Canadian Association of Geographers, Edmonton, 1958, and published with the permission of the Director, Geographical Branch, Department of Mines & Technical Surveys.

TABLE I

NUMBER OF MANUFACTURING PLANTS AND EMPLOYMENT
IN MANUFACTURING IN METROPOLITAN TORONTO,
1945 - 1955[1]

	1945		1950		1952		1954		1955	
	Plants	Employees	Plants	Employees	Plants	Employees	Plants	Employees	Plants	Employees
Toronto	3,482	146,335	4,011	160,063	3,825	149,020	3,728	145,792	3,497	134,235
Forest Hill	1	2			3	10	7	27	11	40
Leaside	47	9,963	50	8,918	61	10,572	56	11,188	50	7,612
Long Branch	16	2,096	34	1,241	29	1,675	29	2,232	26	1,435
Mimico	18	394	31	618	34	629	36	698	44	937
New Toronto	27	7,084	37	6,539	50	7,221	53	7,404	40	7,024
Weston	29	3,180	46	2,716	62	2,830	73	3,560	67	3,951
Swansea	6	606	9	718	13	841	14	687	19	900
Etobicoke	11	254	30	1,180	96	4,311	133	5,797	183	9,106
Scarborough	16	2,835	36	575	115	3,510	148	4,945	212	8,918
York					220	11,730	287	13,605	235	11,715
East York	30	6,322	64	4,605	34	1,239	51	3,516	90	4,708
North York					42	3,163	52	1,265	211	9,771
TOTAL										
Met. Toronto	3,683	179.071	4,348	187,223	4,584	196,751	4,667	200,716	4,685	200,352

from the 1950 peak. In the suburban municipalities manufacturing employment increased by approximately 40,000 in the same period. Nearly all of this growth took place in the new suburbs, manufacturing employment remaining virtually stationary in the older ones. Between 1950 and 1955 a net loss of 514 plants in the city of Toronto was recorded and a net gain of 815 in the twelve suburban municipalities, almost entirely in the new suburbs. Toronto's share in the factory employment of the total metropolitan area decreased from 85% in 1950 to 67% in 1955.

The new suburbs extend in a wide arc to the east, north and west of the city. There is a great deal of urban sprawl, the landscape having undergone rapid and striking, if not somewhat convulsive, changes. A reconnaissance of the new suburban belt from the far eastern to the far western end of Metropolitan Toronto reveals a predominance of residential districts interspersed here and there with shopping centres and industrial areas. In their external aspects, these various types of land use vary little from one suburb to another.

Most of the new suburban factories are medium-sized, one storey, brick buildings, located a hundred feet or so from the road with well-landscaped lawns. (Figure 4) On the other hand there are also many small plants and it is not uncommon to see a row of them built closely together on 75 to 100 foot lots a short distance from the road. (Figure 5) To a large extent industrial districts in the post-war suburbs are clearly separated from residential subdivisions and concentrations of retailing and services. This land use separation is the result of the enforcement of zoning regulations drawn up by Planning Boards in recent years. Only in the older parts of the suburbs does one see a mixed land use of housing and manufacturing. In the most recently developed industrial sections, land use is confined entrely to manufacturing plants, warehouses, wholesale establishments, gasoline service stations and banks.

To investigate factors in the location of new suburban plants and to gain insight into the rise of industrial districts in general, four areas were selected for special study. This was done after a general reconnaissance of the suburbs, consultations with the local planning authorities and a careful scrutiny of the available land use maps. They are located in four of the five new suburbs, two being found in Etobicoke township, one rather large area lying mainly in North York but extending partly into York township and the fourth one being in Scarborough township. In this paper they will be referred to as the Scarborough, North York, Rexdale and Southern Etobicoke sample areas (see Figure 2).

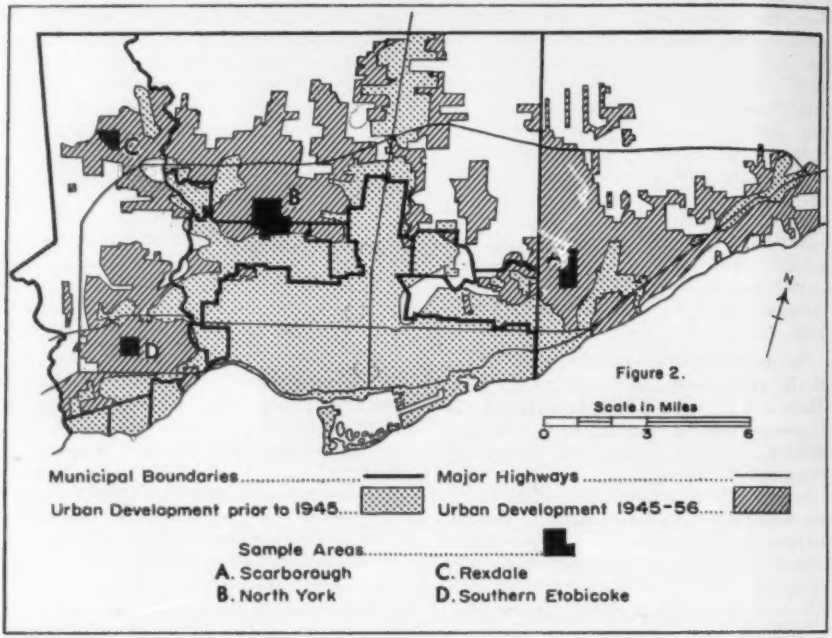
Representatives of the various manufacturing companies in the sample areas were contacted personnally and interviewed concerning their location, a questionnaire being used as a guide. The coverage was virtually complete. Questionnaires were filled out for 182 plants, employing over 10,000 workers in 1957, representing a very substantial proportion of suburban manufacturing.

Industrial development in the four sample areas has taken place recently. In the Scarborough, Sourthern Etobicoke and Rexdale districts, nearly all of the plants have been built since 1950 and between one half and two-thirds in 1956 and 1957. Developments in the North York area began in a modest way before World War II but here also the bulk of the building has taken place since 1950.

Table 2 provides data on the number of plants and employment in each sample area and Table 3 on the size of the firms. Of the 182 firms interviewed, 83 (45%) employed fewer than 25 people, but in turn these plants accounted for just less than 10% of the total employment. In the four sample areas, large plants employing over 200 people were most numerous in Scarborough. The diversity which characterizes manufacturing in the city of Toronto is also found in the sample areas (see Table 4).

PLANT MIGRATION

Development of manufacturing in suburban Toronto results largely from the relocation of existing Toronto firms. Of



the 182 firms contacted, 121 represented enterprises which had a previous location in Metropolitan Toronto, having recently evacuated old and crowded parts of the city.[2] The remaining 61 firms were entirely new business ventures or had come in from other areas, many from the United States of America.

An analysis of plant migration within Metropolitan Toronto showed that industries having built up associations in one part of the city preferred to remain as near as possible to the old location when choosing a new site in the suburbs. Nearly all of the plants in Southern Etobicoke that originated in Metropolitan Toronto had moved from the western half of the city (Figure 3). Similarly, nearly all of the firms migrating to Scarborough came from the eastern half. The North York sample area, having a more central location in the suburban zone, has attracted plants from the entire downtown area. Rexdale in turn has drawn largely upon the northwestern parts of Metropolitan Toronto. This striking pattern in the intra-city migration of plants may be explained by such factors as markets, labour or personal choice.

The most compelling reason which made a manufacturer favour one suburb rather than any other was labour. Permanent employees of a manufacturing company tended to choose a house in the suburbs as close as possible to the plant. Thus companies, when selecting a new location, took into consideration the distribution of their employees in order to avoid the loss of valuable staff. In many ways migration within the city was restricted much more by labour orientation than any other factor, especially when highly skilled and valuable workers were involved.

Similarly, the owner's place of residence may be a decisive factor. In several cases the only explanation for the location of an industry is that the owner already lived in the district. From statistics gathered in the four sample areas, it can be shown that personal reasons strongly affected the location of 33 plants employing 1,097 people, or about 10% of the total

TABLE II

NUMBER OF PLANTS AND EMPLOYEES IN THE SAMPLE AREAS

Sample Area	No. of Plants	Total No. of Employees	Female Employees
Scarborough	44	3,411	990
North York	81	4,086	976
S. Etobicoke	33	1,973	854
Rexdale	24	969	283
TOTAL	182	10,439	3,103

TABLE III

SIZE OF FIRM ON THE BASIS OF NUMBER OF EMPLOYEES IN THE SAMPLE AREAS

	Plants employing between 1 - 9		Plants employing between 10 - 24		Plants employing between 25 - 49		Plants employing between 50 - 99		Plants employing between 100 - 199		Plants having over 200 employees	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Scarborough	6	1.0	13	5.0	9	8.0	7	15.0	2	8.0	7	63.0
North York	17	2.5	18	16.5	23	20.0	14	22.5	4	15.0	5	33.5
Rexdale	4	2.5	6	9.0	7	22.0	4	24.5	3	42.0	0	0
S. Etobicoke	8	2.5	11	8.0	5	8.5	3	8.0	3	19.0	3	54.0
The Four Sample Areas	35	2.0	48	6.6	44	14.1	28	17.4	12	15.9	15	44.0

employment. On the basis of percentage of working force, Rexdale led with 31%, Scarborough and Etobicoke with 10% each and North York with only 6%. Especially small firms of Toronto origin were greatly affected by this personal factor when moving to a new location.

Some firms were more market orientated and selected a suburban site accordingly. For example, in the North York sample area half the plants comprising 37% of the employment in manufacturing transacted more than 50 % of their business in Metropolitan Toronto. Only 16% of the workers in the Scarborough area, 17% in Rexdale, and 24% in Southern Etobicoke worked in plants which had more than 50% of their markets in Metropolitan Toronto.

The importance of the city market for industries in the North York sample area results from the fact that before the building of the main highways in the Toronto area, a location in North York offered relatively easy access to the city. Thus migrating industries with a predominantly Toronto market looked for a north-central location. Since then the

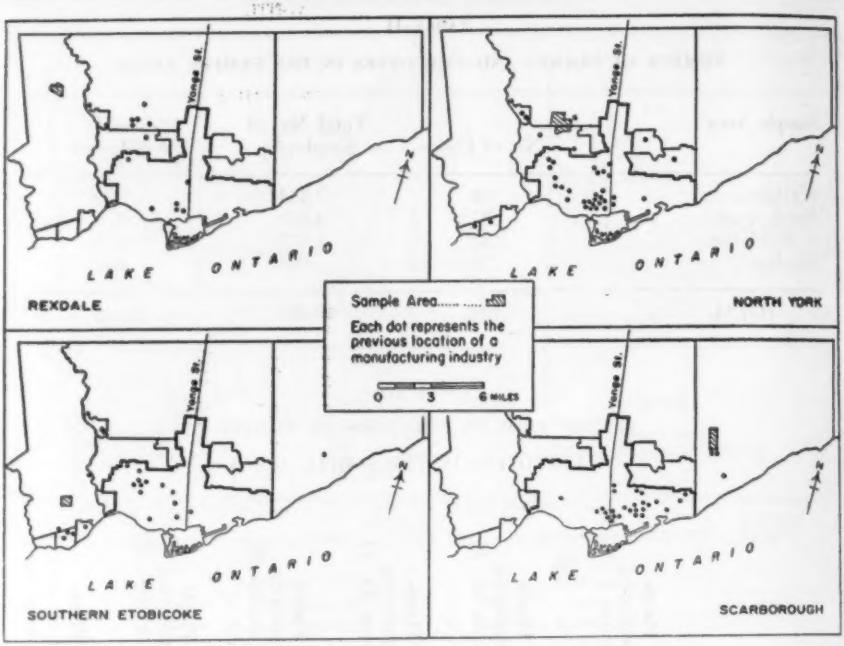


FIGURE 3. Intra-city migration within Metropolitan Toronto.

situation has changed. The building of new highways, in particular the Toronto bypass, has tended to equalize accessibility, on the one hand between the suburbs, and on the other between the suburbs and the city.

In contrast to local firms, those coming from outside Metropolitan Toronto were almost completely free in their choice of a suburban location. Of the few restricting factors, that of market orientation was the most important. Plants have chosen Rexdale to the exclusion of other suburbs because of proximity to the aircraft industry at Malton; a new chemical industry in Southern Etobicoke carries on at least half of its business in Hamilton and, since speed of delivery is essential, a westend suburban location was very desirable.

LAND AND BUILDING

The dominant factor in the location of industries coming from outside is the cost of property. This also applied to local firms but within the suburban area to which they are migrating. Most striking was the fact that of the 182 firms interviewed, 150 listed availability of building or land at a suitable price as the main reason for the choice of their site. The real significance of this is that once a firm decides to locate in suburban Toronto, any site available at a price the manufacturer was willing to pay was probably satisfactory. In short, most manufacturing companies in suburban Toronto are "footloose",[3] and as long as suitable sites are available, manufacturers have a great deal of freedom in the selection of their location. Thus value of land or availability of building become main considerations.

Land values vary with the stage of development of an industrial area, the costs tending to increase as the development of a new industrial quarter proceeds. Manufacturers who are reluctant to pioneer in a newly opened-up area must pay higher

TABLE IV

PERCENTAGE OF TOTAL EMPLOYEES ENGAGED IN VARIOUS TYPES OF MANUFACTURING IN THE SAMPLE AREAS

	Scarborough	North York	Rexdale	Etobicoke	The Four sample Areas
	%	%	%	%	%
Transportation-Aircraft and Automotive	30	11	27	0	17
Electrical Appliances	1	10	23	26	11
Containers, Packaging Materials	17	1	0	29	11
Industrial Machinery	11	13	5	3	10
Building Supplies	3	12	4	6	7
Aluminum Screens and Doors	6	9	0	1	6
Food Processing	1	3	17	13	5
Printing	1	7	0	7	4
Electrical Apparatus and Supplies	11	1	2	1	4
Paints and Varnishes	0	8	1	0	4
Tool and Die making	3	2	10	0	3
Office Machinery and Equipment	7	1	0	0	3
Textiles and Clothing	2	4	0	2	2
Furniture	0	6	0	0	2
Soaps and Cosmetics	3	0	0	0	1
Metal Castings	2	0	0	0	1
Plating	0	3	0	1	1
Toys	0	1	0	5	1
Miscellaneous	2	8	11	6	7

prices for a location in a more fully developed, and thus more firmly established industrial district. It follows that a manufacturer coming to Metropolitan Toronto from outside could very well select a western suburb in one year and an eastern in another year, his choice depending on land values in the various suburbs, and the type of industrial district to which he wishes to become attached.

The change of raw farm land into serviced industrial land is a procedure of some complexity, but it illustrates clearly to what extent personal initiative is of prime importance in suburban factory location. Farm land is prepared for industrial use by a land developer who buys the land either directly from the farmer or from a speculator. Land may pass through the hands of several speculators increasing considerably in price before it is acquired by a developer. Often, the developer is primarily concerned with the building of new houses, but because municipal authorities, seeking balanced assessment, frown on residential expansion without accompanying industrial development, he tries to attract manufacturing. Therefore, the developer may offer very favourable terms to the first industries coming to a new area, and in this way he promotes industrial development. In contrast to the speculator who does not make any improvements on the land, the developer services the land with roads, storm and sanitary sewers and other fa-

cilities. A developer may also go further and erect buildings of a standard format on a speculative basis, or build according to the specification of clients.

Unlike the downtown areas, the suburbs have very few old buildings which manufacturers can rent or buy cheaply. The only important exception is the property of the former munitions plant *Geco* which was purchased by the township of Scarborough from the Federal Government shortly after World War II. Several small manufacturing companies began operations in a variety of buildings and sections of buildings which were then offered for rent or sale by the township. Later, when the more successful industries outgrew their rented premises, most of them decided to move to one of the new industrial districts in the Township, their attachment to Scarborough having been strenghtened over the years. Much of *Geco* still stands, and remains attractive to certain industries, and thus functions as an industrial incubator.

OTHER CONSIDERATIONS

In addition to the factors mentioned so far a few aspects of suburban manufacturing merit attention. Quality of labour in suburban areas is considered to be above average. Some manufacturers mentioned that it is easier to obtain skilled labour in the suburbs than in the downtown area. Being well paid in recent years, many skilled workers have left the city to live and work in the suburbs. Furthermore, most of them are home owners, and in order to meet regular mortgage payments, prefer steady employment and, consequently, absenteeism is not a problem.

For similar reasons, female labour is in good supply. Many housewives are interested in factory work and firms may arrange their working schedules to attract this group. A few industries, however. such as the textile industry, complained that suburban female labour was too expensive. In the four sample areas female labour constitutes almost 30% of the total labour force in manufacturing.

In some districts, residential building lags behind industrial expansion, creating

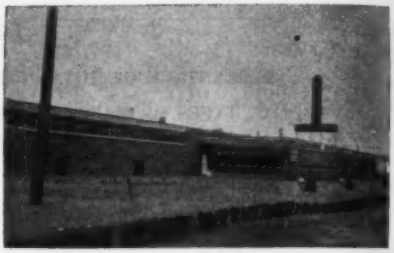


FIGURE 4. A modern suburban plant, taking advantage of the advertising value of its site.

labour shortages. Poor public transportation facilities in suburban areas aggravate this problem. A case in point is Rexdale which in 1956 was in an early stage of development and female labour could not be obtained as easily as in the more fully developed areas such as Scarborough, North York and Southern Etobicoke. Some manufacturers have hired taxis or sponsored car pools to solve these problems.

Transportation facilities exert very little influence on the choice of a site in the suburbs. Industrial lots with or without railway sidings are available in each district. With respect to shipping goods out of Metropolitan Toronto, rail costs and trucking rates are identical from any locality. For example, the rate from Rexdale to Kitchener is the same as that from Scarborough, although Rexdale is approximately twenty miles closer to Kitchener. Traffic congestion is not common in the suburbs but occasionally it constitutes a problem. Some years ago, the North York sample area had some advantages from the point of view of transportation. Now, however, the area suffers a very severe handicap with congestion on the main north-south roads, while other suburban districts have become more accessible.

Among the more intangible factors are those of prestige and advertising. It is difficult to measure the actual significance of these factors in site location. As pointed out before, some manufacturers prefer a fully developed industrial area, and in a few instances this attraction may be reinforced when the district has prestige

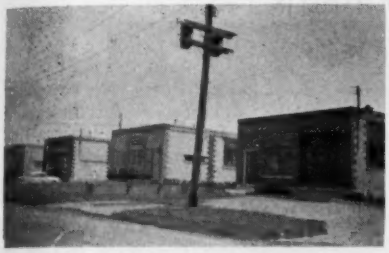


FIGURE 5. A few of the small plants on Crockford Boulevard in Scarborough.

and, as such, advertising value. Areas such as Scarborough's "Golden Mile" have attracted industries for this reason. A plant location on a major highway enjoys much more the advantage of publicity value than that of accessibility. Main highways have only a limited number of access roads on which trucks can enter. Moreover, since trucking rates are virtually equalized, a location some blocks away from the highway has no economic disadvantage except the loss of free advertising. Some highways in the metropolitan area carry between 50,000 and 100,000 cars a day, and it is conceivable that as many as 200,000 people may be exposed to this kind of advertising in a single day. Manufacturers of aluminum awnings and screens are greatly influenced by this factor, (See Figure 4).

CONCLUSIONS

Since 1950 manufacturing in suburban Toronto has expanded greatly. Approximately two-thirds of the development may be accounted for by intra-city migration. Companies coming from outside and new enterprises developing make up the remaining one third.

Most striking is the fact that nearly all industries are "footloose". Markets, labour and personal factors restrict local firms to certain broad areas, within which, however, they have considerable choice in their selection of an industrial site.

The implications are of significance. Any piece of land in the suburbs will, after having been serviced and zoned for manufacturing, attract industries in times of an expanding economy. This being the case, surveys of the suburbs should be made in order to discover the areas most suitable for industrial development. Industrial areas should be selected on the basis of slope, drainage, soil, accessibility, and adjacent land uses. Such planning would eliminate some of the developments now taking place in suburban Toronto. It would avoid innumerable rows of virtually identical houses being spread across level, treeless farmland which, physically, may be better suited for industrial purposes, and it would avoid the use of open, rolling to wooded hilly terrain for industrial and commercial use by levelling the hills and filling the valleys. Usually it is not sufficiently appreciated that such land by its very nature is best suited for attractive residential sub-divisions. Thus an understanding of the forces affecting industrial location in the suburbs makes possible the preparation and implementation of a rational plan to direct all forms of suburban growth.

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LES COURS D'EAU À BERGES FESTONNÉES*

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De 1948 à 1954, au cours d'expéditions[1] dans la région nord-abitibienne des Grands Lacs du 49ème degré de latitude, nous avons découvert une curieuse forme latérale de lit fluvial. Il s'agit d'un micro-relief qui ne semble pas avoir déjà été mentionné dans les études de dynamique fluviale des pays tempérés. Par son dessin, cependant, le *cours d'eau à berges festonnées* ressemble aux "beaded streams", cette forme fluviale originale, connue par les spécialistes, à la fois russes[2] et états-uniens[3] de la géomorphologie arctique; en fait, ce lit "en chapelet", ne tient apparemment pas aux mêmes processus et aux mêmes nuances climatiques que ceux qui commandent l'établissement des berges festonnées.

Nous allons d'abord décrire le phénomène. Nous exposerons ensuite quelques conditions actuelles de l'évolution du relief régional. Enfin, n'ayant pu séjourner longtemps sur le terrain, nous en serons réduit à faire de fragiles hypothèses sur la formation du festonnement des berges fluviales. Bref, l'objet de ce travail est avant tout d'attirer l'attention sur un modèle jusqu'à présent inconnu.

DESCRIPTION

Le phénomène tient essentiellement à la présence locale de long de l'une ou des deux rives d'un cours d'eau d'échancrures semblables évoquant l'aspect d'un intestin grêle. Il s'agit donc de la répétition le long des berges d'une même forme fondamentale: un *lobe* d'eau qui, en plan, est peu profond (100 pieds en moyenne).

C'est dans le bassin moyen de la rivière Bell (Abitibi, Québec) que le phénomène a été découvert dans sa forme la plus pure. Mais de semblables déchirures le long des rives ont été repérées par nous dans la basse Payne (Ungava arctique) ainsi que dans la région du Lac des Bois (Ontario occidental)[4].

Le bulbe fluvial est ordinairement simple et ce n'est que rarement qu'il est imbriqué dans une arcature. Il ressemble à une moitié d'ovale dont la dimension longitudinale (à la rivière) peut être jusqu'à six fois plus élevée que le rayon transversal par exemple, 600 pieds contre 100. Nous remarquons en outre que le rapport des rayons axiaux et perpendiculaires varie en fonction de la largeur et du débit du cours d'eau: plus la rivière est importante, plus les lobes sont larges mais peu pénétrants; inversement, sur les ruisseaux, pour une même distance, les festons seront plus nombreux et leur concavité relativement plus accusée (en ce cas, le rayon tend à n'avoir qu'une seule et même valeur). De plus, le rayon longitudinal correspond ordinairement à la largeur du lit ordinaire du cours d'eau: cette similitude donne une dimension telle que le lobe ne peut être un méandre de la rivière; d'ailleurs, cette poche d'eau s'inscrit indifféremment le long des courbures concaves ou convexes d'anciens grands méandres fluviaux. Enfin, l'intérieur du lobe est parfaitement arrondi comme s'il s'agissait d'une plage de régularisation.

Là où l'écoulement semble être de sens irréversible, le lobe qui est toujours limité par des pointes aiguës est dissymétrique à la fois, dans sa courbure et dans ses pointes frontières qui s'effilent timidement en flèche vers l'aval. Les pointes n'ont rien des pédoncules de méandres et dans les ruisseaux à plus faible puissance d'érosion elles peuvent s'avancer jusqu'au milieu du lit. Cela n'empêche pas l'ensemble des pointes de ne pénétrer que jusqu'à un même point dans le cours d'eau de manière à laisser libre un espèce de chenal linéaire central. Nous retrouverions un semblable calibrage si nous examinions les limites de pénétration de chaque concavité dans l'interfluve; nous avons un peu l'impression qu'il doit y avoir un facteur uniformisant et régularisateur dans l'élaboration, dans l'entretien ou dans la modification du phénomène.

Cette forme élémentaire — *lobe* d'eau limité par des *pointes* bordières — ne

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* Presentée à la huitième réunion annuelle de l'Association Canadienne des Géographes, Edmonton, 1958.

FIGURE 1. Cours d'eau à berges festonnées, Ruisseau Gizzard, Bassin de la rivière Bell. (photo A.R.C.) Train de festons droits, à pointe effilée, visibles des deux côtés du cours d'eau. Nous n'avons pas trouvé de rives où les festons étaient mieux développés qu'ici. La valeur moyenne du rayon des concavités s'établit à 100 pieds.

semble pas se rencontrer à l'état isolé; du moins, dans la région, ne l'avons-nous pas vue qu'en groupe. La répétition de ce lobe concave vers le bassin et à pointe dressée dans le lit crée un *train de festons* fluviaux long parfois d'un mille. Il arrive même au ruisseau Gizzard d'avoir sur ses deux rives les berges entièrement enguirlandées. Si, ordinairement, ces échancrures ne se trouvent pas partout, elles semblent indifférentes aux rives concaves et convexes; elles le sont également à la largeur du cours d'eau, c'est-à-dire que l'on rencontre des festons sur des rivières de différents niveaux hiérarchiques. Si les lobes existent des deux côtés de la rivière, le rayon a tendance à prendre une même valeur mais les festons d'une rive ne semblent pas tenir une position complémentaire de celle des festons de l'autre: nous voulons dire qu'une pointe sur une rive peut avoir comme vis à vis aussi bien une pointe qu'une concavité comme si des conditions locales travaillaient indépendamment sur chaque berge. Vue d'avion, la distribution des trains de festons ne semble pas tenir compte de la nature de la végétation car nous trouvons des séries de lobes dans les forêts de conifères, dans des talles reboisées de feuillus, dans les broussailles et dans les "tourbières"[5].

Ainsi apparaissent les cours d'eau à berges festonnées. Le tracé en plan d'une série de concavités et de pointes rapelle le profil d'un pont découpé en arches que soutiennent des piliers également espacés et enfoncés. Cette forme originale semble tellement liée au cours d'eau qu'il nous faut maintenant examiner les conditions du travail fluvial.

CONDITIONS DE LA DYNAMIQUE FLUVIALE ACTUELLE

Comme il s'agit d'un phénomène récent, nous nous en tiendrons exclusivement à l'examen des éléments actuels de la morphogénie fluviale locale.

Les cours d'eau à berges festonnées que nous venons de décrire coulent dans une zone de matérieux meubles fins et postglaciaires; le "bed rock" n'apparaît pas en surface. C'est, de plus, un matériel de fine texture: limon, argile et sable; donc un matériel facilement transportable; aussi, les eaux sont-elles sales et de goût terreux.

Ces rivières ont en outre une pente excessivement faible car elles coulent dans une zone où l'accumulation (postérieure) a été à peine suffisante à combler ce qui a pu être un jour une dépression glaciaire. Par suite de cette faible inclinaison longitudinale et d'une charge en matériaux fins relativement élevée, les rivières n'ont pas un tracé inamovible; nous pourrions facilement reconstituer dans la région l'histoire des déplacements des talwegs. Fait probablement indicateur de l'âge du festonnement, les chenaux les plus récents sont exempts de concavités.

Si les plus petites unités hydrographiques sont situées dans des zones planes, les pointes des festons sont longues, droites ou même déviées vers l'amont. Cela semble être le témoignage d'une inversion du courant fluvial. Ces oscillations dans le sens de l'écoulement s'expliquent probablement par un reflux de l'eau du collecteur dans ses affluents ou par l'action de barrages locaux.

Un autre indice de l'évidement difficile de cette partie du bassin se voit dans la forte proportion de l'eau dans les dépôts superficiels; la couche de saturation semble être près de la surface; les festons sont donc installés dans une zone mal drainée, ce qui n'est pas indifférent à l'action répétée de la gélivation.

De plus, cette forte humidité du sol favorise la croissance de certaines éricacées, de sphaignes, de plantes hydrophiles. Or, ce tapis végétal, élastique, est apte à encaisser, mieux que des sédiments terrestres, l'action de divers processus morphologiques mineurs. Il semble bien qu'une phase de conquête végétale a précédé l'installation des croissants sur les berges.

Les cours d'eau à berges festonnées sont situés aux limites de la région tempérée froide et de la zone subarctique; nous sommes loin au Sud du permafrost contigu mais de rares poches d'eau nous font supposer la présence de quelques lentilles internes de glace. L'enneigement est abondant, le coefficient de "glacement"[6] relativement élevé. L'été est

chaud. Il ne s'agit donc pas de conditions climatiques arctiques. Dans la classification générale proposée par J. Tricart, la région considérée se rattacherait au domaine "continental de la zone forestière des latitudes moyennes"[7].

En fait, la latitude basse peut tromper car les cours d'eau étudiés ici (réseau de la rivière Bell) coulent du Sud vers le Nord, c'est-à-dire qu'à la débâcle, l'amont étant dégagé plus tôt que l'aval, les embâcles, les débordements et les inversions de courant sont facilement possibles.

Ainsi, on le voit, les conditions d'écoulement qui président à l'élaboration du modelé des berges festonnées sont de type spécial; l'argent fluvial doit faire des concessions à divers éléments locaux qui troublent son action "normale".

PROCESSUS

Faute de séjour sur les lieux durant la saison morphologique principale (de mi-avril à mi-juin), nous ne connaissons pas l'explication des cours d'eau à berges festonnées. L'on nous permettra cependant de signaler, à titre indicatif seulement, les divers processus possibles.

L'action fluviale semble être prépondérante. Cela se voit à l'intégration même des festons dans le lit, au calibrage des pointes, à l'étirement de ces dernières dans le sens du dernier courant puissant, à la construction des flèches et au modelé de confluence.

Mais s'agit-il d'une action fluviale "normale"? M. H. Baulig à qui nous avons montré des photos de festonnement de rives[8] a posé l'hypothèse de l'emboîtement de méandres mais il lui a semblé difficile de prendre les échancrures et les pointes pour des concavités et des pédoncules de méandres.

Il est logique également d'imaginer des courants fluviaux circulaires qui, en se déplaçant avec le flot, tailleraient, d'amont vers l'aval, le long des rives, des lobes successifs et de même taille.

Nous sommes plus sûr d'une certaine action latérale; il semble que, dans certains cas, le lobe d'eau corresponde à la confluence d'un petit affluent ou au site d'une source; il se peut, qu'en ces points, l'agitation de l'eau ou le déglacement tardif restreigne l'accumulation et l'emprise de la végétation au bénéfice de sections situées immédiatement en amont ou en aval. Là où ce processus joue, la pointe serait l'élément dynamique dans le festonnement et nous serions en présence d'une modification morphologique qui utilise la complicité du facteur végétal.

Il serait étonnant que le rôle des glaces de couverture n'y soit pour rien mais il n'est pas facile d'entrevoir comment ces glaces interviennent dans le façonnement des berges festonnées; en effet, le modelé délicat et régulier de ces dernières est tout autre que le relief brutal de poussée, une des caractéristiques majeures de l'action des glaces flottantes. Il se peut cependant que l'incidence majeure de ces glaces se fassent plutôt par l'intermédiaire d'une expansion et d'une occupation différentielles de l'englacement sur les rives: les lobes étant, différemment des pointes, "pris", puis libérés, par les glaces.

Mais cette hypothèse suppose l'existence d'un certain festonnement antérieur. Ce préalable est peut-être l'heureux indice que les cours d'eau à berges festonnées ne sont pas monogéniques et qu'il faille distinguer entre les processus de première phase (installation d'une échancrure banale le long d'une rive) et les processus postérieurs qui améliorent et qui entretiennent le festonnement.

CONCLUSION

Les cours d'eau à berges festonnées ont donc leurs rives découpées en *lobes* d'eau limités par des pointes aiguës: une série d'échancrures fait un *train de festons.*

Même si le phénomène est récent, il n'est pas exclu de voir dans le festonnement des berges un certain héritage d'un modelé peu ancien que commandaient, entre autres, des lentilles internes de glace; il fut un temps sub-actuel où la section étudiée de la rivière Bell connaissait un climat de type subarctique. Si le festonnement semble être une forme partiellement *héritée*, elle n'est pas pour cela *figée.*

Ce relief original tient, semble-t-il, à une dynamique fluviale qui fait des concessions à la surcharge en matériaux fins,

à l'inversion de l'écoulement, à la colonisation végétale, à l'alimentation latérale, à l'englacement différentiel et, peut-être, à des courants circulaires. Il s'agit donc d'un phénomène polygénique.

Le répérage systématique de ce modelé n'est pas encore assez avancé pour que ces exemples isolés soient définitivement considérés comme zonaux. De même, l'insuffisance des informations limite ce que nous pouvons savoir de certain au sujet de ce nouveau phénomène qui doit rester à l'étude.

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MOUNTAIN-TOP DETRITUS AND THE EXTENT OF THE LAST GLACIATION IN NORTHEASTERN LABRADOR-UNGAVA*

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The term 'mountain-top detritus' is used here to designate a specific type of boulder field formed by the disintegration of bedrock in situ by frost-shattering[1]. Whether or not mountain-top detritus can be invariably distinguished from other types of boulder fields depends upon the bedrock, type, and especially upon the development of joining within the bedrock, and also upon location. The ideal end product for ease and certainty of interpretation — angular frost-shattered bedrock — is not always produced, and in certain circumstances great care must be exercised in differentiating between ground moraine, for instance, from which the fines have been washed by running water, and frost-shattered bedrock.

The importance of frost-shatter[2] in the formation of mountain-top detritus has long been assumed, but there has been much disagreement on the length of time necessary for mature development. A mature form is here defined as a mantle sufficiently deep to mask the strike and dip of the underlying bedrock. Odell[3] and Tanner[4], in discussing the glaciation of Labrador-Ungava, assume that post-glacial time has been sufficiently long for the formation of the mountain-top detritus that is to be found today in various parts of eastern Canada. Many other workers, including Tansley[5] and particularly Dahl[6], argue that the mature development of detritus requires a much longer period, and that mature forms probably ante-date the last glaciation. This controversy leads to one of the most important aspects of the significance of mountain-top detritus. If agreement can be reached regarding the time factor, it may or may not be possible to use the presence of mature detritus as an indication of the persistence of an ice-free area (nunatak) during the maximum of the last glaciation. The purpose of this paper is to examine this possibility with respect to Labrador-Ungava in particular, and to the marginal areas of past ice sheets in general.

Owing to lack of quantitative work on the process of frost-shatter, progress must depend in the first place upon a theoretical consideration of the problem, and in the second place, upon deduction from the variations in detrital mantle both horizontally and vertically, and upon the evaluation of associated evidence.

As suggested in the opening paragraph, the importance of rock type in any theoretical consideration cannot be over-emphasised. In other words, on different rock types, and even on the same rock type with local variation in the development of joint patterns, frost-shattering will tend to produce different mantles with respect to degree of angularity and size of the individual pieces. For example, well jointed igneous rocks, such as granite, will break down under prolonged frost-shattering into a deep mantle of angular blocks of varying size, dependent upon the spacing of the joints. This type, mainly because of its extreme angularity, can be easily differentiated from water-washed moraine, where a certain degree of rounding is usually apparent. It might be expected that foreign material within the moraine would be an important diagnostic characteristic, but in an area of granite and gneiss, such as north-eastern Labrador-Ungava where great local variations in rock type occur, this is not the case. Moreover, as indicated below, erratics are found within and upon true mountain-top detritus.

Angularity, however, is not invariably a characteristic of the detrital mantle. Finely-banded gneisses provide every

* Presented at the Eighth Annual Meeting of the Canadian Association of Geographers, Edmonton, 1958. The work in 1956 and 1957 was made possible by generous grants from the Banting Fund, administered by the Arctic Institute of North America, and by air transport kindly provided by the British Newfoundland Exploration Company. The writer is indebted to Prof. R. F. FLINT for discussion and advice on the significance of the high-level erratics in the Torngat Mountains, to Dr. E. P. WHEELER 2nd, for stimulating discussions and information of surface types outside the areas of study, and to Dr. Eilif DAHL for his published work and his very helpful correspondence on the problems considered in this paper.

FIGURE 1. View from base camp towards the east-northeast in the Nakvak Trough. The well pronounced lateral moraine-kame terrace complex can be clearly seen, above which the bedrock is shattered for 450 feet (137 m.) giving incipient mountain-top detritus, although the original glaciated surface is apparent upon examination in the field.

variation from large angular blocks to small rounded pebbles and fine gravel within a short horizontal distance. Adamellite breaks down rapidly under frost action, the feldspars splitting out, and forms a deep mantle of gravel.[7] Limestone, on the other hand, breaks down rapidly to form a mass of thin plates. From this consideration it becomes apparent that careful discrimination over a wide area in general, rather than dependence upon local features, is necessary before a safe interpretation of the superficial mantle can be made. Similarly, as it must be assumed that speed of shattering will vary according to rock type, certain rock types, such as limestone, may have to be eliminated from the consideration because they break down so rapidly that a mature detrital mantle may possibly have developed in post-glacial time.

Dahl,[8] in considering the marginal slope of an ice sheet adjacent to deep water, concluded that the maximum marginal slope physically possible is of the order of 1 : 100, and therefore, mountain summits, exceeding 1,000 meters in height, will project at nunataks for up to 100 km. from the edge of an ice sheet. If Dahl's criteria are accepted, the Torngat Mountains can be described as marginal; in other words, it might be expected that certain of the high coastal summits could never have been inuntated by ice, however extensive the glaciation. It is upon these summits, therefore, that mountain-top detritus may be expected to exist.

It is striking that the broad upland summits of the Torngat Mountains carry a deep cover of mountain-top detritus. However, erratic blocks are found within and upon the detrital mantle to heights exceeding 5,000 feet (1524 m.) above present sea level.[9] Furthermore, unequivocal erratics of gneiss have been found resting upon Mugford volcanics within 200 feet (60 m.) of the summit of Mount Brave in the Kaumajet Mountains.[10] This summit exceeeds 4,000 feet (1219 m.) and directly overlooks the coast suggesting that, although Dah'l theoretical concept of the marginal slope of an ice sheet is probably correct in general, the figure of 1: 100 for the maximum possible slope wille have to be modified. Thus Dahl's correlation between an assumed marginal slope of an

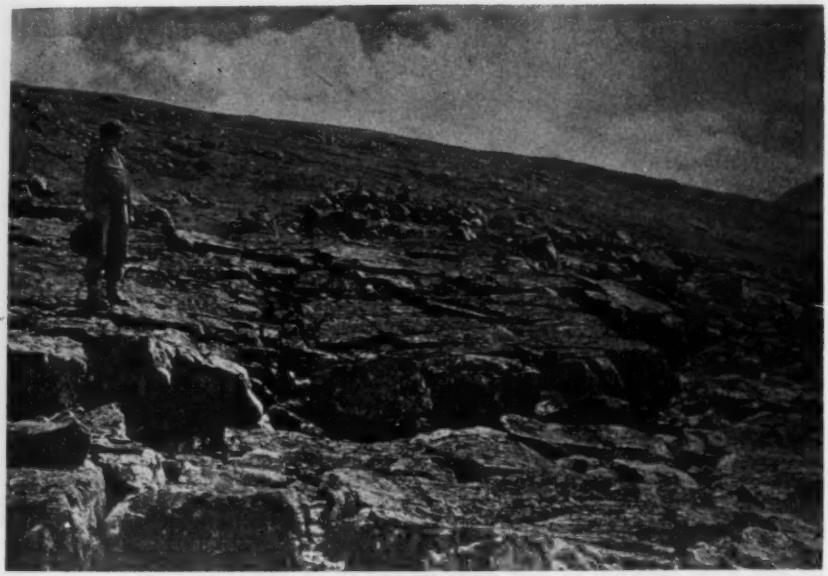

FIGURE 2. Post-glacial frost action is breaking up the glaciated surface exposed above the lateral moraine-kame terrace complex resulting in the formation of "incipient" mountain-top detritus.

ice sheet and the persistence of nunataks, and hence mountain-top detritus, does not appear to be completely valid.

The existence of the high-level erratics within and upon the mountain-top detritus in the Torngat Mountains adds to the complications of the problem of its full interpretation. In this same area, however, it appears that the emplacement of the high-level erratics ante-dated the final glaciation.[11] Kame terraces and lateral moraines, associated with an extensive system of former ice-dammed lakes to the west of the present watershed, were traced over a considerable distance during the summer of 1957. Between 400 and 450 feet (122 - 137 m.) above the main lateral moraine — kame terrace system glacially-scoured bedrock predominated, whilst above this again a deep mantle of frost-shattered bedrock (mountain-top detritus) covered all the gentler slopes. This dividing line between mountain-top detritus above, and glaciated bedrock and moraine below, has been interpreted as the trimline of outlet glaciers passing through the Torngat Mountains at the maximum of the last glaciation.

The restriction of mountain-top detritus to land above this upper trimline, taken in conjunction with the evidence of the inferred glacial lakes and the lateral moraines and kame terraces, leads to the conclusion that the high-level erratics date from an earlier glaciation which was much more extensive than the last, and that the mature detritus has been developing *in situ* from the time that the upper slopes were first exposed with the thinning of the earlier ice sheet. The final glaciation overtopped the lower inland summits west of the watershed, but its outlet glaciers were confined to the main through-troughs and transection valleys, thus sweeping away all detritus in their paths and forming the trimline at their upper limits. This does not preclude the possibility that semi-permanent snow and thin ice patches occupied sections of the higher land during the last glaciation. Such a condition, in fact, seems highly probable.

Mountains in the vicinity of the water-

FIGURE 3. Development of periglacial surface forms on the upper slopes which remained above the level of the continental ice sheet during the final (Koroksoak) glaciation. Note angular form of detritus.

shed which rise to 2,500 feet (762 m.) have bare, glacially-scoured bedrock to their very summits; occasional glacial grooves have been preserved and erratics are numerous. On the higher summits to the east, however, which were above the limit of the last glaciation, erratics are few and far between (in fact, erratics were found on only four of the nineteen summits which were ascended, and these are invariably massive blocks of granite or granite-gneiss. The parent rocks of these erratics were probably massive, with widely spaced joints, so that the blocks were once bounded by joint planes, and the absence of joints within the blocks has permitted their long preservation despite the ravages of frost action which have completely split up the more closely jointed rocks upon which they rest today.

Examination of bedrock surfaces below the upper trimline adds further support to the hypothesis. Frost-shattering has certainly been active, but in most places, especially upon fairly massive granite and granite-gneiss, the original glaciated rock surface is well preserved, although it may be split in places. On banded gneiss incipient mountain-top detritus may be found, but again, the original form of the glaciated surface is usually distinguishable.

It is apparent, therefore, that mountain-top detritus may be used as an indication of the persistence of ice-free areas in the Torngat Mountains throughout the last glaciation, and the initiation of the detritus may be assigned to the closing phases of the penultimate glaciation. The correlation of the two most recent Torngat glaciations with the standard chronology of central North America is not yet possible. The earlier of the two (Torngat Glaciation) may be of Illinoian age, or it may be post-Sangamon and pre-Wisconsin. The final (Koroksoak) glaciation is probably the equivalent of the 'classical' Wisconsin.[12]

Data are much too scant to allow an expansion of this method to the entire coast of Labrador but observations from two other localities are worthy of consideration. In the Makkovik area, south of Hopedale, summits rise to between 1,200 and 2,000 feet (609-914 m.) above

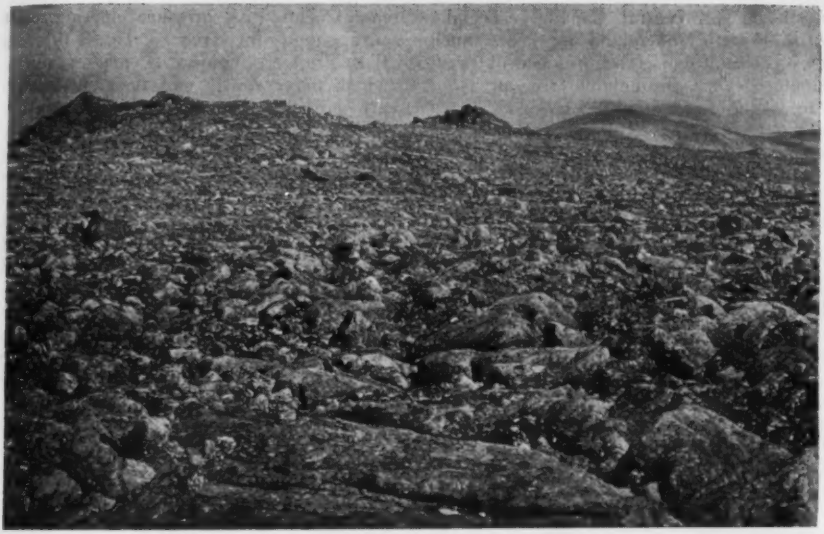

FIGURE 4. Development of sub-rounded mountain-top detritus on gneissic rocks.

sea level near the coast. Here the summits carry very delicate glacial striae where the rocks are fine-grained, and even on coarse-grained granite-gneiss the larger grooves and crescentic fractures are well preserved. The conclusion is that the freshness of these forms results from their formation during the final glaciation when the ice sheet completely inundated this entire area. Preservation of these forms is an indication that frost-shattering has had little chance to break up the surface completely during the short time since these summits emerged from the last ice sheet.

North of Nain, in the vicinity of Webb Bay, Mount Thoresby exceeds 3,000 feet (914 m.) and lies on the outer coast. Because of its height and position it may be anticipated on theoretical grounds that this summit might carry a deep mantle of mountain-top detritus. Information supplied by Dr. E. P. Wheeler implies that this is, in fact, the case. The neighbouring Kiglapait Mountains, however, which rise to 2,900 feet (883 m.) appear to carry no detrital mantle and it seems, from the observations of Mr. Tony Morse, McGill University Department of Geological Sciences that they were completely inundated by ice during the final glaciation. These observations, however, were made at random and further verification is necessary. On the other hand it may be noted that the Kiglapait lie to the west of Mount Thoresby, that is, in the direction of increasing thickness of the last ice sheet, whatever the marginal slope. From the evidence so far presented, and from a general knowledge of its topography, it seems likely that few other places on the Labrador coast have been favourable for the formation and preservation of a deep cover of mountain-top detritus. The Kaumajet Mountains are a distinct probability, and the eastern end of the Mealy Mountains may be well worth investigation.

Whether or not these findings can be applied to other parts of the Canadian Arctic and Subarctic depends upon a much fuller knowledge of conditions, and upon much more detailed work in those areas where the relationship between mountain-top detritus and ice-free areas during the final glaciation seems well established. Also, quantitative work on the process and rate of frost-shatter on different types of rock would be invaluable. Conditions in

northern and central Canada, especially in high arctic and inland areas, are much more complicated. The presence of frost-shattered rock throughout large areas of the Canadian Arctic which have almost certainly been covered by ice sheets during the final glaciation seems to deny the possibility of the wide application of this method. Yet great differences in topography occur and the physical conditions of the ice sheets and outlet glaciers must have differed considerably with increasing latitude. Boyé[13] was greatly impressed by the apparent ineffectiveness of glaciers as agents of erosion in the Ata Sund area of west Greenland. Similarly, in north-western Ellesmere present-day glaciers appear to have the ability to over-ride laminated sands and gravels without disturbing the laminae.[14] The classification of glaciers proposed by Ahlmann[15] emphasises the importance of the physical conditions of the ice. Hight arctic glaciers are those which, apart from the upper few feet during the ablation season, remain below the pressure melting point throughout the year. These glaciers therefore, are cold stiff masses of ice which move slowly and their melt-waters are supra- and intra-glacial, rather than sub-glacial. This latter point is very important when it is considered that sub-glacial streams are very effective agents of erosion and of transport. It is reasonable to assume that the effectiveness of glaciers as agents of erosion, and also of transport, is at least reduced under cold conditions. It is suggested, therefore, that a cold ice sheet, moving across a large area of relatively slight relief, such as the central Canadian Arctic, has not the ability to sweep before it the entire surface mantle.

Wide application of the concept that the presence of mountain-top detritus indicates the persistence of nunataks is not possible at the present state of knowledge, but in certain areas, and especially where high mountains occur near the margins of former ice sheets (for southern Baffin

FIGURE 5. The mountains on the Nakvak-Koroksoak divide are glaciated to heights exceeding 2,500 feet (762 m.) above present sea level. The preservation of the glaciated pavement and grooves is evidence that this summit (2,500 feet) was actively eroded during the final (Koroksoak) glaciation.

Island, see Mercer,[16]) and even lowland areas beyond the reach of the ice sheets, this concept may prove of considerable use in the evaluation of the extent and thickness of the last ice sheets.

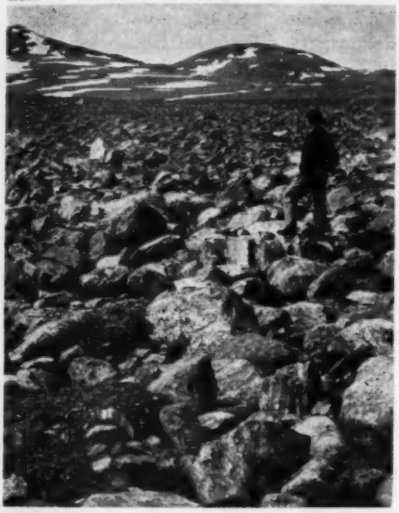

FIGURE 6. The lower slopes are frequently mantled by extensive fields of boulders which may be easily misinterpreted as 'mountain-top detritus'. The presence of sub-rounded and rounded blocks is evidence that these boulder fields are formed from glacial moraine, the fines of which have been washed out by running water.

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GLACIOLOGICAL RESEARCH IN NORTHERN ELLESMERE ISLAND*

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Rather more than half of northern Ellesmere Island is covered by ice at the present time; there are about 10,000 square miles (25,900 sq. km.) of ice cap and glaciers. It is perhaps surprising that the second most northerly land in the world is not more extensively ice-covered; the relatively thin and limited ice cover of this region is in striking contrast to the great mass of the Greenland ice cap, centred many miles to the southeast. As in the northernmost part of Greenland, the reason for the apparent anomaly is the very low precipitation, which averages only about 4½ inches (11.5 cm.) water equivalent at Alert in the extreme northeastern corner of Ellesmere Island. A 20 to 30 mile (30-50 km.) strip of land bordering the north coast of the island is ice-free except where it exceeds about 4,000 feet (1219 m.). The ice cap immediately to the south, which reaches a general level of 6,000 to 6,500 feet (1829-1981 m.), with nunataks perhaps as high as 9,000 feet (2743 m.), constitutes a reservoir of ice accumulated in a period of more abundant precipitation.

For about 55 miles (90 km.) westward from Cape Columbia the north coast is fringed by an ice shelf, which also occurs discontinuously in most of the fiords and bays further west. Recent work has shown that the ice shelf originated not through land glaciers pushing seaward, but through the ability of great thicknesses of sea ice to form off this coast and remain fast. In this region sea ice formation is favoured by great winter cold, low summer melt and low precipitation. Upward growth of the ice shelf took place through freezing of sea-water on the lower surface and also through snow accumulation and firn formation at the upper surface. There is evidence that the Ellesmere Ice Shelf is a product of the deterioration in climate which has taken place since the Climatic Optimum, 4,000 to 6,000 years ago. In contrast the ice cap is a survival of the much greater, perhaps complete ice cover of northern Ellesmere Island in earlier times.

To fill a gap in glaciological knowledge of the far north the Defence Research Board organized an International Geophysical Year expedition to northern Ellesmere Island to study the ice cap and to make meteorological observations over a period of eighteen months. The base camp for the 1957-58 expedition was established in the Lake Hazen area which seems to enjoy a somewhat sheltered climate for this latitude. Lake Hazen was discovered by Greely in 1882 on the First International Polar Year Expedition. The last expedition to visit the lake was the Oxford University Ellesmere Land Expedition in 1935.

The glaciological and meteorological programmes were designed to provide information on the regime of the ice cap, that is the balance between accumulation on the one hand and ablation and movement on the other. There were indications that the ice cap is in a better state of health than ice caps and glaciers studied in regions further south. It was recognized that, although precipitation is small, not much melting takes place above about 5,000 feet (1524 m.); much of the collecting ground is situated at or above this altitude.

Below Mount Oxford (7,200 feet - 6584 m.) on the ice cap, at 6,000 feet (1829 m.), a pit 20 feet (5.8 m) deep was dug for accumulation, density and temperature measurements in the snow and firn. In the budget year 1955-56 the net accumulation was 13½ inches (34.3 cm.) of firn or 6 inches (15.2 cm.) water equivalent; in 1956-57 the total accumulation, measured before the melt season, was 13 inches (33 cm.) of snow or 4½ inches (11.4 cm.) water equivalent. Most of the ice layers observed in the pit were probably annual markers, so that the bottom of the pit corresponded to the early 1930's. Vertical "ice glands", due to the downward percolation of melt water, were also observed

* Based on a lecture delivered at the 51st Annual Meeting of the Canadian Institute of Surveying, and published by permission of the Chairman, Defence Research Board of Canada.

showing that appreciable melting occurs at this altitude. At depths of 13 to 20 feet (4.0-5.8 m.) the temperature in the pit remained steady at —9°F. (—22.8°C.) which is probably very close to the mean annual temperature at this altitude.

To the north of Mount Oxford glaciers descend abruptly to the valleys at the head of the fiords of the north coast, where melt water had already collected on the glacier surfaces by 25 June. Southeast of Mount Oxford the ice cap falls away much more gradually than to the north, but crevasses up to 100 feet (30 m.) or more in depth occur near nunataks or where there are occasional sharp changes in the slope of the underlying rock.

The firn line is situated at an elevation of between 4,000 and 4,500 feet (1219-1370 m.) on the south side of the mountains. Seismic soundings by Dr. F. S. Grant showed that the ice is up to 2,000 feet (609 m.) thick in this area. Lower down at an elevation of 3,400 feet (1034 m.) an advanced camp was established on Gilman Glacier. The depth of snow in the spring, averaged from ten stations over the whole width of the glacier, was only 9 inches (22.9 cm.) or 2½ inches (6.3 cm.) water equivalent. The average ablation here up to August 6th. was 28 inches (71.1 cm.) of ice or 24 inches (60.1 cm.) water equivalent. The amount of ablation varied across the glacier, but was generally greater on the east side where on account of winddrift there was less snow in the spring. Near the snout of the glacier the ablation was probably as much as 3 feet (0.9 m.) water equivalent. Temperature studies at the camp down to a depth of 50 feet (15.2 m.) in the ice indicated a mean annual temperature of about 0°F. (—17.8°C). The rate of movement here was 3 inches (7.6 cm.) per day.

The summer melt gives rise to many interesting features. Towards the end of June the exposed rock of nunataks provide centres of heat from which the melted snow runs down in streams to form lakes on the glaciers, even up to an elevation of 5,000 feet (1524 m.). By the end of the summer these lakes may be several hundred yards across. In deep cores in suitable places on the ice cap it would not be surprising to find lenses of lake ice suggesting past fluctuations in climate. The most striking features of the melt streams are the rapidity with which they form in the latter half of June and the way in which they concentrate the melt water to the drainage channels at the sides of the glacier where large lakes are formed. The surface level of one of these lakes fell 55 feet (16.7 m.) in one week after the breaching of a snow dam lower down, leaving distinct strand lines and rafts of ice above the shore. Since there are no crevasses in the lower eight miles of Gilman Glacier, the melt water cannot reach the floor of the glacier to emerge in subglacial streams at the snout, but cuts deep channels in the glacier surface. The two main streams which flow on the gravel flats below the glacier snout come from the lateral drainage channels; they are joined by a number of smaller streams which form waterfalls over the terminal ice cliff. In mid-summer the main river is a rushing torrent 30 yards (27.4 m.) wide and much too swift to ford. The great influx of water into Lake Hazen from this and other rivers is a major factor in causing the melting of the ice on the lake; in 1957 the lake was completely ice-free by the end of the first week in August.

Gilman Glacier is as much as 1,200 feet (366 m.) thick within two miles of its snout according to Dr. Grant's seismic soundings. Any change in the position of the frontal part of the ice cliff of Gilman Glacier between early June and early August was less than a few inches according to an accurate chain survey. Willows, saxifrage and moss grow close to the foot of the ice cliff. On both sides of the snout the marginal streams are eroding heavily into their banks the tops of which are well vegetated and only a few yards away from the vertical ice cliff. The snout appears to have been more or less stationary over the past few decades or to have advanced slightly. Past stands of the ice are represented by a recessive series of old marginal drainage channels on the hillside 450 to 600 feet (137-183 m.) above the entrance of the gorge cut by the river and up to 2½ miles (4 km.) from the present glacier snout. This reces-

sion took place a very long time ago as shown by the deep gorges cut by the rivers from the present marginal channels. An Eskimo tent ring in the valley to the west of the snout of Gilman Glacier is situated less than a mile from the ice cliff of the glacier near the head of this valley. The tent ring has probably been in existence and the valley consequently ice-free for at least several hundred years.

The survey control for the geophysical work was established by K. C. Arnold by means of a subtense bar traverse, starting at the Geodetic Survey "Shoran" station on Johns Island. The work was efficiently carried out by the extended base method with two Wild T.2 second-reading theodolites and a Wild invar subtense bar. Dogteams were used on the glacier and ice cap for transporting instruments and camping equipment. The survey work also included the setting up of a triangulation network for observations on glacier movement stakes.

From the meteorological records of the weather stations at Alert and Eureka and records on Gilman Glacier the budget year 1956-57 in northern Ellesmere Island was marked by lower precipitation and, in the ablation season, by higher temperature than in an average year. The highest temperature was 46°F. (7.8°C.) on 24 June. Figures for accumulation on Gilman Glacier and on the ice cap tend to confirm the abnormally low precipitation. The observations of J. R. Lotz showed that, once the melt was under way, the amount of ablation was directly related to the daily maximum temperature. Cloudiness, sunshine and wind speed showed little definite correspondence. This was also found to be true on the Barnes Ice Cap in Baffin Island. Radiation measurements were not made in 1957 but it is hoped that they will form part of the 1958 programme.

It is tentatively concluded that Gilman Glacier lost rather more ice by ablation than it gained by accumulation during the budget year 1956-57. A fuller appreciation of the regime of Gilman Glacier and of the ice cap must await further data over a wider area on accumulation, ablation and movement which it is hoped to obtain in the field season of 1958.

In this high latitude, the winter cold is very great and the ablation season short. It is therefore not surprising that, in spite of the light snowfall, the ice cap and glaciers of northern Ellesmere Island appear to be more or less in a state of balance, while glaciers in the temperate regions have shown a general recession in the past few decades, although this recession may now have passed its peak.

It appears that the climatic amelioration. which culminated in the late 1930's or early 1940's, has had less effect on the ice cover in northern Ellesmere Island than in other parts of the Arctic, as for example northern Norway and Spitsbergen.

CRYOCONITE PHENOMENA ON THE GREENLAND ICE CAP IN THE THULE AREA*

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During the last decade glaciological research into snow and ice phenomena has received increasing attention. Investigations have been carried out on a number of features in order to understand the existing ice regime more fully. Among those processes which play a significant part in the melting of ice and snow in Arctic regions is the work of cryoconite phenomena. In August 1949, the writer studied cryoconite phenomena in the ablation zone of the Greenland Ice Cap in the Thule area, northwest Greenland, and this paper presents quantitative data collected at that time on cryoconite holes, or 'dust wells' and also on cryoconite stripes and cryoconite cover.

The purpose of this paper is to present the results of field investigation, thus supplying more quantitative data on cryoconite phenomena than has previously been presented for the northernmost areas of the Arctic. But in addition, it is hoped that it will stimulate more interest among geographers in such studies and direct their attention toward the possible use of the research data for practical purposes.

CRYOCONITE AND CRYOCONITE HOLES

The term 'cryoconite' was introduced by A. E. Nordenskjöld[1], who, during his first expedition to the Greenland Ice Cap, observed numerous water-filled cylindrical holes sunk into the ice. The bottoms of these holes were covered with dust a few millimetres thick. This powdery dust he called "cryoconite' from the Greek *kruos* (ice) and *konis* (dust). Consequently, the forms which resulted from differential melting under cryoconite on the ice were called cryoconite holes, and the process of melting and deepening of the holes was called cryoconite or indirect ablation.

Because of an erroneous impression that the original term suggested a cosmic origin, numerous writers unhappily used such terms as dust, detritus, dirt, debris, etc., to describe the phenomena instead of the original term. The cryoconite holes were named 'ice wells" or 'dirt wells'. To eliminate confusion the writer prefers the use of the original term 'cryoconite' defined as fine, or very fine, dark, windblown, inorganic or organic or both, sediment deposited on snow or ice surfaces which under solar radiation cause the cryoconite phenomena.

A number of writers have discussed the formation of cryoconite holes, notably among them Steinböck[2]. The initial stage appears to be the accumulation of the cryoconite sediment in small depressions on snow or ice surfaces, considerably lessening the tremendous reflective capacity of snow and ice. The solar radiation absorbed by the cryoconite is changed into thermo-energy causing excessive melting of the ice around and below it. The cryoconite sinks down into the ice vertically, forming cryoconite holes. Both direct and indirect solar radiation take part in the process of deepening the cryoconite hole, although the latter is thought to be mainly responsible for deepening the holes in northern latitudes. Both types may act either directly on cryoconite or be transmitted through the snow, ice or water.

Following Nordenskjöld's[3] work, cryoconite holes attracted the attention of many explorers and investigators, chiefly Scandinavian and German, although English-speaking explorers took part to a lesser degree.

Drygalski[4] made one of the more outstanding contributions, basing his work on observations and measurements made in 1891/1892 during two reconnaissance trips to Itivdliarssuq (70°45'N., 50°10'W.) and Sermiliq Fiords (70°35'N., 50°20'W.), and on a major expedition to the Great Karajak Glacier (70°25'N., 50°15'W.). He gave a detailed description of cryoconite holes, and in measuring 205 of them found 115 showed an average width of 5 to 10 cm. and a depth of 40 to 60 cm. One of his important statements was that cryoconite was not ephemeral in

* Presented at the Eighth Annual Meeting of the Canadian Association of Geographers, Edmonton, 1958, and published with the permission of the Director, Geographical Branch, Department of Mines & Technical Surveys.

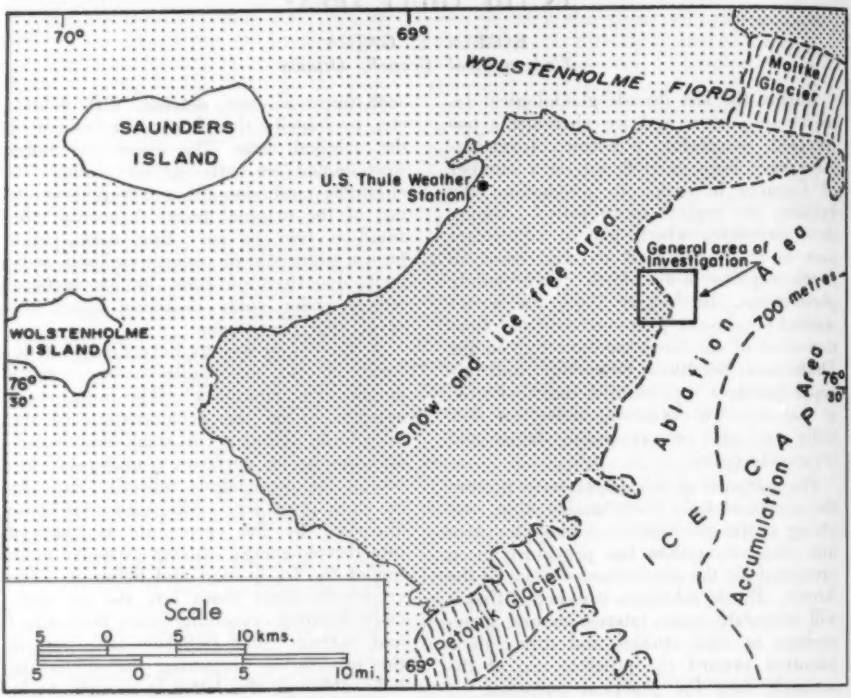

FIGURE 1. Location map.

character, but accumulated in the holes over many years, being more or less enriched every year by new deposition.

Steinböck investigated the ice and glacier of Disko Island in 1935. Although he never encountered the typical cryoconite holes, his theorical study, based mainly on the findings of other researchers, supplied valuable information on the nature, morphological characteristics, formation and evolution of cryoconite phenomena in general, and in polar regions in particular. The main contribution, that of the classification of cryoconite holes morphologically into two types, namely polar and alpine[5], and all other hollow forms as pseudo-cryoconite, helped to avoid confusion in nomenclature. On the basis of his biological studies he expressed the opinion[6] that the permanent cryoconite horizon represented a well established life association and life environment of micro-organisms such as algae, protozoa, etc. He further suggested that because of these cryoconite holes this cryoconite life outlasted the Ice Age in situ[7].

STUDY AREA

The area under investigation lies roughly 14-15 km. (8.7 - 9.3 miles) southeast of Thule U.S. Weather Station at about 76°34'N. and 68°15'W. (Figure 1). It appears to be the northernmost locality of investigation of cryoconite holes to date. In this area the Greenland Ice Cap rises gently at an angle of 6 degrees toward a dome-shaped gigantic ice structure obstructing the horizon to the south. The elevation of the locality was 1360 ft. (414 m.).

The marginal zone of the ice cap is flat-lying and comparatively smooth. Farther away from the margin it is cut by numerous rivulets. Not a single stone

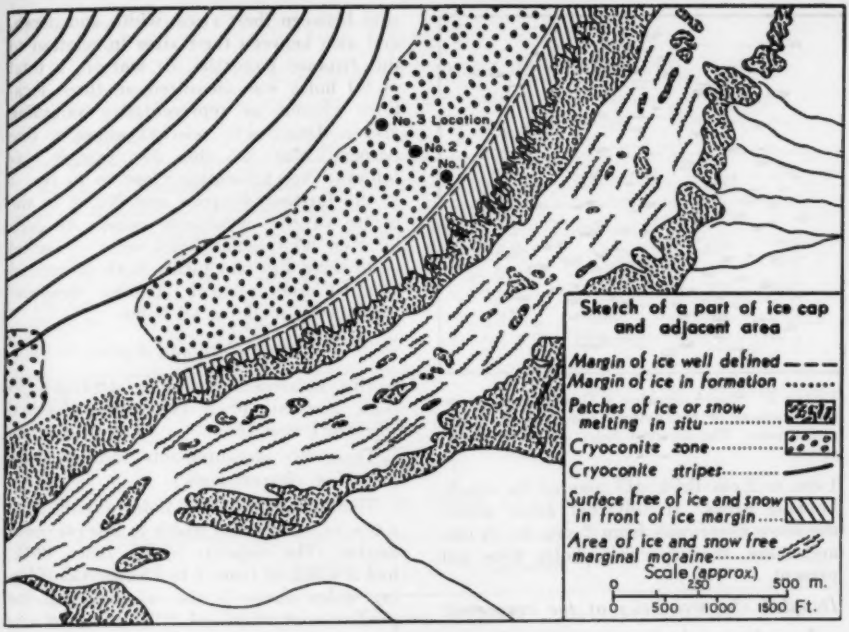
No. 3 Location
No. 2
No. 1
Sketch of a part of ice cap and adjacent area
Margin of ice well defined
Margin of ice in formation
Patches of ice or snow melting in situ
Cryoconite zone
Cryoconite stripes
Surface free of ice and snow in front of ice margin
Area of ice and snow free marginal moraine
Scale (approx.)
0 250 500 m.
0 500 1000 1500 Ft.

FIGURE 2.

or boulder covers its surface. Part of this area, however, adjacent to the ice margin, is dotted with countless cryoconite holes.

The margin of the ice cap is a well defined line which separates it from the adjacent snow and ice-free belt of marginal moraines. Immediately in front of the ice margin and in the depressions between morainic ridges and humps and mounds, the remnants of previous years' snow were melting in situ (Figure 2).

Beyond the morainic belt to the north and northwest the terrain falls rather abruptly to the floor of the broad glacial valley and then slopes more gently toward North Star Bay and Wolstenholme Fiord.

For convenience the area in which the cryoconite holes were present will be called the cryoconite zone. It lies in the ablation area of the Greenland Ice Cap, which in the Thule region extends to an elevation of 700 metres (2,296 ft.). A firn line runs approximately along this contour, separating ablation and accumulation areas[8]. The cryoconite zone appears like a huge sponge from the air, with holes unevenly distributed. Although some holes occur singly, in the majority of cases they form bigger or smaller clusters, with sizes intermingling freely (Figure 3). Smaller hollows appeared to be more abundant. The great majority of the holes were circular in shape, with corresponding cylinders of varying depths. The walls of the hollows were straight, vertically positioned and partially or fully filled with water (Figure 4). No oblique positions were observed. The water surface of some of the holes was frozen, forming a thin cover of clear ice up to 5 mm. thick. The rims of the majority of holes were well defined. The bottom of the holes was covered by very fine, black, slimy sediment up to 10 mm. deep. It was practically odourless, suggesting a small amount, if any, of organic material. All holes close to the ice margin were formed on snow-free ice, whereas toward the centre and farther to the opposite side, wet snow

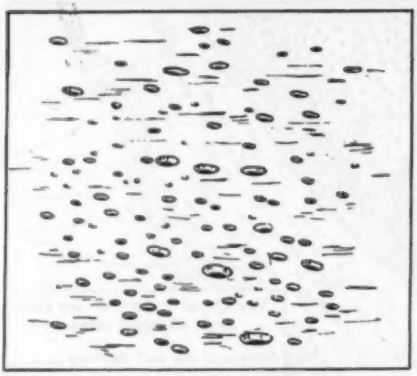

FIGURE 3. Sketch showing a cluster of cryconite holes typical of the pattern found in the cryoconite zone. The smallest holes are undeveloped tubes.

1 cm. to 2 cm. thick still covered the neighbouring areas. In adjacent areas where the snow cover was from 2 cm. to 15 cm. and more, the cryoconite holes were not present.

Detailed characteristics of the cryoconite

In order to obtain quantitative data on the morphological characteristics of cryoconite holes and to examine any relationship between their sizes, width and depth, and also between their sizes in relation to the distance from the ice margin, a total of 90 holes was measured on three locations chosen as representative sampling areas. They were selected along a line perpendicular to the ice margin, as follows: No. 1 location close to it, No. 3 at the farthest distance and No. 2 in the centre of the cryoconite zone. At each location 30 circular holes were measured as to their size and form. Both horizontal (width) and vertical (depth) measurements were made of all holes.

Sizes (width and depth)

The measurements were arranged in class intervals of 5 cm., and tabulated (Tables I and II).

These 90 measurements indicated the following characteristics:

The diameter of the holes varied from a few millimetres in width to several centimetres. The majority of the holes, 86%, had a width of from 2 to 15 cm. Considering holes above 5 cm. in diameter, the predominant width of 68% of them was between 5 and 15 cm. The holes between 10 and 20 cm. in depth accounted for 45% of all holes. In addition the deepest

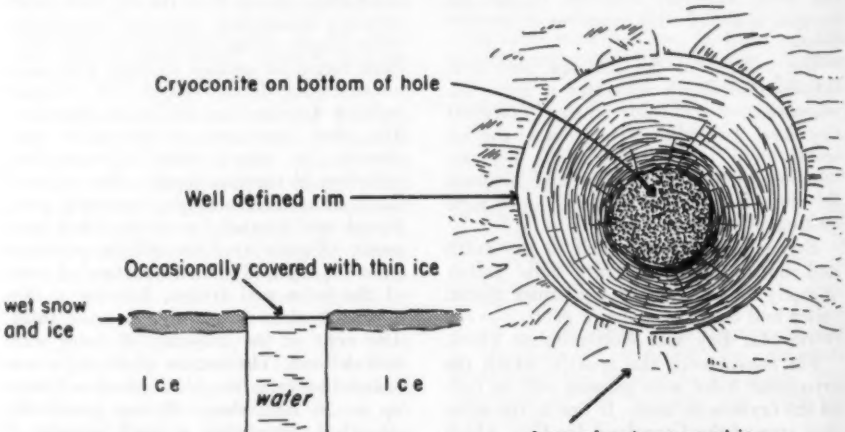

FIGURE 4. Sketch of a typical, well developed cylindrical hole. Original size 10 cm. x 10 cm. x 20 cm.

TABLE I

WIDTH OF CRYOCONITE HOLES IN CENTIMETRES

Location 1		Location 2		Location 3			
Width	Number	Width	Number	Width	Number	Total	%
below 2	scarce	below 2	abundant	below 2	abundant		
2- 4.9	5	2- 4.9	9	2- 4.9	11	25	28
5- 9.9	7	5- 9.9	11	5- 9.9	16	34	38
10-14.9	10	10-14.9	5	10-14.9	3	18	20
15-19.9	5	15-19.9	3	15-19.9	None	8	9
20-25	4	20-25	2	20-25	None	5	5
Total	30		30		30	90	100%

TABLE II

DEPTH OF CRYOCONITE HOLES IN CENTIMETRES

Location 1		Location 2		Location 3			
Depth	Number	Depth	Number	Depth	Number	Total	%
below 2	scarce	below 2	abundant	below 2	scarce		
2- 4.9	10	2- 4.9	3	2- 4.9	None	13	14
5- 9.9	9	5- 9.9	5	5- 9.9	2	16	18
10-14.9	7	10-14.9	8	10-14.9	4	19	21
15-19.9	4	15-19.9	10	15-19.9	8	22	24
20-24.9	None	20-24.9	4	20-24.9	11	15	17
25-30	None	25-30	None	25-30	5	5	6
Total	30		30		30	90	100%

hole found was 32 cm. and the largest 26.5 cm. in width. Only 5 holes were counted with a depth of between 25 and 30 cm., all at location No. 3 farthest from the margin of the ice. No holes of from 2 to 5 cm. were found in this locality. In contrast, at location No. 1 no holes with depths exceeding 20 cm. were found, while the majority (19) were between 2 and 10 cm. deep. Holes of lesser depth with diameters below 2 cm. were abundant in the centre of the zone, but diminished in number toward the peripheries. A width of individual holes exceeding 15 cm. was rather rare. No holes of this size were present at locality 3 and there were only a few at locations 1 and 2. In all probability they were the result of coalescence of two or more individual holes.

The greatest density of holes was in the centre of the zone where 95 holes of all sizes, including underdeveloped tubes, were counted on an area of 1 square metre. This density diminished to 58 holes toward the ice margin. No counting was done at location 3 farthest from the margin, but it was estimated that the density there was somewhere between the two above-mentioned figures.

Forms

The surface form of holes observed was circular (rounded) (Figure 4), elliptical (oval) or irregular, with an estimated proportion of about 80%, 15% and 5% respectively. A few holes of smaller size resembled a kidney shape (Figure 5).

The corresponding cylinders had, in all cases, vertical straight walls (Figure 4). In the case of elliptical forms, the amount of ellipticity was comparatively small; in the majority of cases the difference between the longer and the shorter axis was less than 4 cm. Some of these elliptical forms were not fully developed (Figure 5).

Types

The classification of types was made on the basis of evolution. Two types were distinguished: simple and united.

The first type represented a single hole being developed from a small tube several millimeters in diameter to full mature size both horizontally and vertically. By far the greatest number of holes were of the simple type.

The second or united type represented a hole developed to greater size due to the coalescence of two or more neighbouring simple forms. In only a few cases could definite coalescent forms be observed with their walls separated by thin ice on both sides, and the centre part of the walls already melted.

It is possible that the occurrence of united holes is more frequent than was observed. This was, however, difficult to determine, especially in the case of smaller holes, due to the advanced stage of their development.

In all probability the complete melting of the walls had already occurred at this time of year.

Theoretically a coalescence of two or more holes of different depths could occur, resulting in a compound form with an uneven bottom on different levels. However, no such case was observed in this area.

Seasonal cycles in cryoconite hole development

From all the measurements made, no definite relationship (parallelism) could be found between depth and diameter of the holes, in the sense that reduced depth and smaller diameter, or greater depth and larger diameter, could be correlated. Both dimensions varied even in the neighbouring holes, and could not be related. However, a relationship between the depth of the holes and their distance from the ice margin was indicated. With increased distance from the ice margin the depth of the holes increased. Twenty-six holes out of 30 at the location closest to the ice margin were less than 15 cm. in depth, whereas at the location farthest from the ice margin, 24 holes out of 30 were from 15 to 30 cm. deep (Table II.). Such large differences can hardly be explained by differences in solar radiation in a comparatively small area; other factors must be involved. As was previously mentioned, the cryoconite zone in this area is adjacent to the snow and ice free marginal moraine. In summer the temperature over the marginal moraine could rise well above the freezing point. On August 10th the temperature of the air 1 m. above the ground was 45°F. (7.2°C.), while over the ice close to the margin it was 37°F. (2.8°C.), dropping to 33°F. (0.5°C.) on the opposite side of the cryconite zone. Although these measurements serve only as an indication of local changes, it can be assumed that temperatures well above the freezing point occur over periods of time. These micro-climatic conditions would affect the cryoconite zone closer to the ice margin to a greater degree than the area farther from it. Accordingly, the increased direct ablation of the ice surface nearer the ice margin would overcome cryoconite ablation, reducing the depth of the cryoconite holes in this area. In some cases holes would be destroyed altogether, accounting for the scarcity of smaller holes in this part of the cryoconite zone. These micro-climatic conditions would become less effective farther from the ice margin, where the deepest and best developed holes are found (Table II).

It therefore appears that seasonal short climatic cycles which would be best developed at this time of year are directly

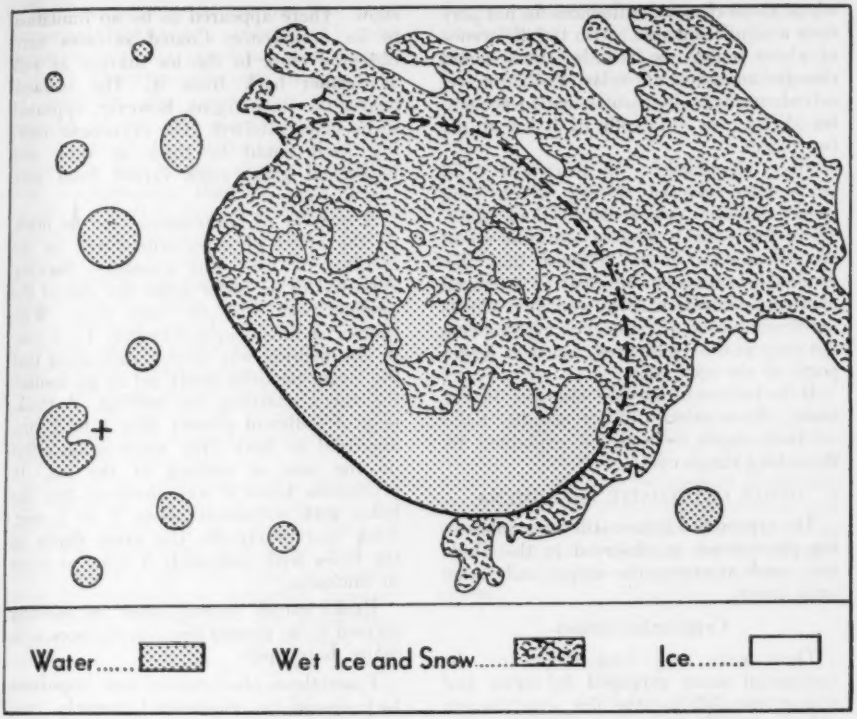

FIGURE 5. Air view of a large elliptical hole not completely developed. Original size 17 x 23 cm. The continuous line indicates well defined rim; the broken line the rim marked by ice and snow. Small simple holes surround the large form. The hole marked by a cross is believed to be of the united type.

responsible for the inferior state of development of cryoconite holes in the areas adjacent to the snow and ice free surfaces, and the superior state of development farther from it.

Long range cycles

Some interesting facts can be noted by the comparison of the main characteristics of the cryoconite holes in the Thule area in 1949 with those taken by Drygalski some 58 years ago, 6 degrees to the south. Generally, the main characteristics of the cryoconite holes correspond with those observed by Drygalski, with the exception of one main factor, i.e. the depth. The most common depth of the cryoconite holes in the Thule area in 1949, at the location farthest from the ice margin and considered to represent the best developed cryoconite holes, was from 15 to 25 cm. (Table II), with the deepest hole 32 cm. The most common depth reported by Drygalski was calculated at between 40 and 50 cm. with the deepest 66 cm. in depth. This comparison shows that the holes in the Thule area were less than half as deep on an average, and almost half as deep in the case of the deepest holes, as those measured by Drygalski. This large difference can hardly be explained by the short climatic cycles already mentioned, particularly in view of the fact that the measurements chosen for comparison were characteristic for the location farthest from the ice margin

where those climatic influences do not play such a significant role. Also the difference of about 6 degrees latitude which would change amounts of solar radiation received, seems to be insufficient to account for differences in depth of holes at the two places.

Since Drygalski's measurements, 58 years have elapsed during which long range climatic cycles have taken place. There has been a general warming-up of arctic regions. It is believed that this gradual warm-up has resulted in increased melting in northern areas and now affects the development of cryoconite phenomena, not only in the Thule area, but over larger parts of the continent .

It is believed that the changes in the main characteristic of cryoconite holes — their depth — can be explained by these long range cycles.

OTHER CRYOCONITE PHENOMENA

The cryoconite induce still other interesting phenomena as observed in the Thule area, such as cryoconite stripes and cryoconite cover.

Cryoconite stripes

These were very long stripes on the surface of snow arranged in series and almost parallel to the ice cap margin (Figure 2). The stripes were formed due to the deposition of very thin cryoconite sediments undoubtedly by wind action. They could be observed very well from the air at the margin of the cryoconite zone in its ice cap side between the elevations of approximately 1400 and 1700 feet (426-518 m.). Investigation on the ground showed that the sediment deposited in each stripe was very thin, reddish brown in colour, and consisted of very fine particles probably of mineral origin. All stripes were approximately 10 cm. wide. The surface under each stripe was only slightly depressed due to thawing, apparently indicating its recent formation. As no references could be found to this phenomena in the literature, they were called 'cryoconite stripes'.

Cryoconite cover

A surface coating of cryoconite was deposited by wind action on the ice and snow. There appeared to be no limitation to its occurrence. Coated surfaces were observed close to the ice margin as well as farther back from it. The surfaces nearer the ice margins, however, appeared to be more affected. The cryoconite coating itself could be thick or thin, and individual grain sizes varied from very fine to coarse.

A number of observations can be made on the effect of cryoconite cover on the melting of ice. For example, thawing appeared to be faster when the size of the particle was fine or very fine. With coarser sediment approximately 1 - 2 mm. in size melting was slower, indicating that the larger particles likely act as an insulating cover retarding the melting. A thickness of sediment greater than 1 to 2 mm. appeared to have little appreciable effect on the rate of melting of the ice. In cryoconite holes it was observed that the holes with sediments about 1 to 2 mm. thick had practically the same depth as the holes with sediments 5 mm. or more in thickness.

Under evenly coated cover the melting seemed to be greater than on surfaces with many bare spots.

From these observations one important fact should be emphasized, namely, that the rate of melting of ice and snow surfaces is in direct relation to the thickness of the cryoconite coating. Thinner cryoconite layers accelerate the thawing apparently due to their greater heat absorption, while thicker layer have a delaying effect on melting because of their greater insulation capacity.

No observation could be made of the effect of the composition of cryoconite on thawing of ice, but it was assumed that this factor also plays a significant role.

PRACTICAL APPLICATIONS

The role of cryoconite in melting processes is still not completely known or understood, because of a lack of more detailed data on the multitude of factors involved. Undoubtedly it is manifested regionally in higher and lower latitudes where it has an effect on the melting of glaciers, ice and snow surfaces of land, rivers, lakes and seas.

In this process in nature two most important factors are present: (1) solar radiation with its powerful heat energy, and (2) the cryoconite with its capability of lessening the tremendous reflective capacity of ice and snow surfaces. The net result of the action of these two factors is the release of thermo-energy and, consequently, thawing. One factor involved in this process, namely solar radiation, is constant. The other factor, cryoconite, is variable and could be replaced by artificial matter — dust. If dust, resembling the main properties of cryoconite could be spread over snow and ice it would create, under favourable conditions similar melting phenomena to those which occur in nature under cryoconite. The result would be the accelerated melting of snow and ice surfaces and possibly their earlier destruction.

There is no evidence in the literature that artificial dusting of snow and ice has been attempted in Canada although there are indications that some work in this connection has been done in clearing snow from airfields. It is known, however that Russian researchers are conducting experiments in the thawing of snow and ice by artificial dusting, apparently with good results [9, 10, 11]. The problem of thawing of ice and snow is important to Canada with its vast Arctic regions, particularly in view of steadily increasing interest in the north and in development programmes for the territories. Here the artificial dusting for practical purposes could be used in (1) agriculture (i.e. the lengthening of a comparatively short growing season), and (2) in navigation, where the lengthening of navigation periods in northern ports (i.e. Port Churchill) is one of the most important problems. In addition, the problems of the prevention of spring ice jams at the mouths of rivers, and early clearing of rivers to avoid floods, await solution.

Artificial dusting could also be successfully used to speed up the thawing of snow and ice around icebound ships, in places of winter standstills for ships, in approaches to locks in canals, in the vicinity of piers and docks etc.

With regard to the practical application of the data derived from the studies of forms, types and the development of cryoconite holes, it is suggested that such information would give valuable assistance to the solution of problems connected with vehicular and other movement over snow and ice surfaces covered by cryoconite holes.

To assist in the development of the technique a wealth of data should be obtained from observation of cryoconite phenomena in different regions and under different climatic conditions. Detailed quantitative data are necessary for each factor involved. This is a field in which geographers can make a valuable contribution. The information acquired would be of the utmost importance to those seeking a practical solution to the problem. Complete data would assist in the establishment of formulae for dusting under various conditions. It should then be possible to compute the amount of dusting needed, and the required composition and physical properties of the material to be used in any one situation for the acceleration of the rate of melting of ice and snow.

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SHORTER COMMUNICATIONS — BRÈVES COMMUNICATIONS

CANADIAN ASSOCIATION OF GEOGRAPHERS EIGHTH ANNUAL MEETING

The 8th annual Meeting of the Association was held at the University of Alberta in Edmonton from May 28th to May 31st. This was the most westerly (and northerly!) meeting of the Association but despite the distance, 56 delegates registered. Most welcome guests were Dean Chauncy Harris, President and official delegate of the Association of American Geographers and Prof. J. Grenville Jensen, President, Association of Pacific Coast Geographers and Mrs. Jensen.

The first day of the meeting was devoted to Alberta and the Prairies, with discussions on Edmonton and Calgary, and various aspects of physical and economic greography. A short tour was made of the Edmonton area. The second day was divided into four periods dealing with the Canadian Far West and North-West, the Mediterranean, physical geography of Canada and Eastern Canada.

On May 30th, an extensive tour was made of the environs of Edmonton, although unfortunately heavy rain made it necessary to change the route from that planned and in the evening the session on Eastern Canada was completed. The final session on Saturday morning was devoted primarily to geography in schools.

The annual general meeting was held on the evening of May 29th. This was followed by the presidential address when Dr. Trevor Lloyd spoke on "The geographer as citizen". The President also mentioned several achievements of the past year among them being the fact that the membership is now over 200, that *The Canadian Geographer* is now printed by letterpress, exchange literature is now deposited permanently at Carleton University and a formal exchange of delegates has been arranged with the Association of American Geographers. The results of the election of officers was announced and the chairmen of committees were appointed as follows: Awards — W. C. Wonders; Editorial — N. L. Nicholson; Education — T. Hill; Membership — J. K. Fraser; Convention — C. S. Brown; Program — T. Weir.

L'ASSOCIATION CANADIENNE DES GÉOGRAPHES HUITIÈME ASSEMBLÉE ANNUELLE

La huitième assemblée annuelle de l'Association canadienne des géographes eut lieu à l'Université d'Alberta à Edmonton, du 28 au 31 mai. Ce fut l'assemblée de l'Association tenue la plus à l'Ouest (et au nord!), mais en dépit de la distance, 56 délégués se sont enrégistrés. Les invités les plus appréciés furent le doyen Chauncy Harris, président et délégué officiel de l'Association américaine des géographes, et le professeur J. Grenville Jensen, président de l'Association des géographes de la côte du Pacifique et Mme Jensen.

La première journée de la réunion fut consacrée aux provinces de l'Alberta et des Prairies avec des discussions sur Edmonton et Calgary ayant rapport à différents aspects de la géographie physique et économique. Un tour de courte durée fut organisé dans la région d'Edmonton. La deuxième journée fut divisée en quatre périodes traitant de l'Ouest et du Nord-Ouest canadien, de la gréographie physique du Canada et de l'Est du Canada ainsi que de la Méditerranée.

Le 30 mai un tour prolongé était organisé dans les environs d'Edmonton mais malheureusement la pluie obligeât les responsables de changer leurs plans, cependant la séance sur l'Est du Canada fut complétée dans la soirée. La séance finale du samedi matin fut consacrée principalement à la géographie dans les écoles.

L'assemblée générale annuelle fut tenue le soir du 29 mai suivie de l'allocution du président M. le docteur Trevor Lloyd intitulée "Le géographe comme citoyen". Le président passa en revue plusieurs accomplissements de l'année précédente, notamment le nombre des membres se chiffrant maintenant à 200 et le fait que *Le Géographe Canadien* est maintenant imprimé par procédé typographique. De plus, les échanges de publications sont maintenant déposés d'une manière permanente à l'Université de Carleton et un échange officiel de délégués a été arrangé avec l'Association américaine de géographes. Les résultats des élections des officiers furent annoncés et les présidents des divers comités sont maintenant comme suit: Octrois — W.C. Wonders; Rédaction — N. L. Nicholson; Education — T. Hill; Recrutement — J. K. Fraser; Convention — C. S. Brown; Programme — T. Weir.

B. CORNWALL

THE USE OF THE METRIC SYSTEM IN GEOGRAPHICAL PUBLICATIONS

The decimal basis of the metric system and the existence of metric units of measurements which can be derived from each other in all fields of scientific inquiry, have so recommended the metric system that since its inception in 1801 it has been officially adopted by the governments of about 60% of the world's population. By and large only the English-speaking world and the areas controlled by it have not officially adopted the metric system. Nevertheless in areas where the English system is officially used, the metric system is increasingly used in most scientific fields.

Because of the many advantages of the metric system as a system of measurements, and because of its increasing status as the universal system the Executive Committee of the Canadian Association of Geographers suggests that geographers present all measurements in their published works in the metric system, or at least in the metric system as well as the English system.

MICHEL BROCHU

USE OF HAND-SORTED PUNCHED CARDS IN GEOGRAPHICAL RESEARCH*

In geography, as in other fields, data have been expanding at such a prodigious rate that it is no longer easy for one individual to cope with the mass of scientific and technical knowledge appearing regularly in the literature. If the geographer is to make full use of the record, data must be organized and filed in such a manner that they are immediately accessible. Punched cards will, at least, help to solve the problem. Although punched cards are being employed successfully in a very wide range of research, a perusal of the literature reveals no reference to their use in the field of geography. Perhaps this lack of enthusiasm stems from an impression that punched cards systems are too complex and costly to fit into the individual research program. However, complex machines are only part of the story; simple, hand-sorted systems are available to the individual researcher and are a most satisfactory and cheap research tool.

There are two major uses of punched cards in geographical research. The first great use is the ease with which the literature may be searched for relevant data, and the results reduced to writing. Many of the old-time mechanical operations of reading and sorting cards are simplified. The usual method of report writing is to prepare an outline, and then to insert the pertinent data in their logical places. This procedure involves the selecting, sorting, arranging and correlating of large masses of data. Providing that the coding and abstracting of the data has been adequate, the use of punched cards will greatly facilitate the mechanical aspects of the problem. Other aspects of technical writing, such as the arrangement of the bibliography, which usually involve much tedious sorting of cards and papers, can rapidly and easily be handled with the use of punched cards. Cards can remain in the file in any order, so there is never a re-filing problem. The other great advantage is in the easy correlation of research data, and the establishment of cause and effect relationships. There are, of course, problems inherent in any correlation attempt, such as the possibility that any two phenomena seeming to be in correlation may depend on a third factor as a common cause. In geography, where often the amount of data is meagre, the possibility of pure chance is relatively great. Therefore standard statistical tests for correlation should be carried out once the data have been sorted by the use of punched cards.

The equipment used in the hand-sorted punched card system is exceedingly simple and well described in the literature. It consists of the punched cards themselves, the hand puncher and the sorting tool. There are many commercial punched cards on the market, and they are manufactured in sizes ranging from 1½ to 2½ inches to 8½ by 10 inches. The largest size is commonly used for research purposes. Of the commercial punched cards the McBee Co. "keysort" is probably the most satisfactory. The "keysort" card has one or two rows of ⅛ inch holes, four to the inch, parallel to the edges of the card. Most of the area of both sides of the card is available for writing, typing or printing of references, abstrcts, observational or numerical data. A special punching device, very much like a train conductor's punch, is available for coding the card. The card is punched along the outer edge forming slots where holes were before. The simplest sorting machine is a stylus smaller in diameter than the hole; a knitting needle would serve the purpose, although the commercial sorter is very inexpensive. It consists of a convenient four and a half inch handle to which is mounted a semi-flexible steel shaft much like a shoemaker's awl.

The actual process of entering the information on the card presents few problems. It can be done by handwriting, typing, sticking of printed matter, etc. No definite rule can be given as to how much information should be entered on the card. Information should be in a concise form because of space limitations. Summaries of experimental work may be entered, as well as notes on conversations with workers in the same field of interest, or correspondence with others on the topic under consideration.

The most important step in setting up a punched card system is to develop a suitable code for punching purposes. It should be simple, a point often overlooked, for the very flexibility of the system and its wide range of possibilities may beguile the beginner into creating a code in which every shade of meaning is possible, but which is unwieldy to use in actual practice. In the development of a code one should start which general concepts which can be used frequently as a basis for further extension of the code. As one gains experience working with the problem, and with the cards, one can expand the system. By proceeding in this manner it is often possible to avoid disappointments caused by inconsistencies and other inadequacies of a superficially attractive code unable to meet the test of actual use. The code must be based on a well-defined, carefully selected terminology and it must be used in a consistent, standardized fashion when incorporating new items into the file. The purpose the system will serve must be fully analysed before an attempt is made to reduce the code to writing. It may be advisable to use the punched cards as a general file first, before attempting to punch them into code. In this way experience in consulting the file may be used as a basis for discovering which terms and concepts are most helpful in carrying out the type of sorting required. It may be necessary to accumulate perhaps a thousand cards before the subject matter is analysed for the last time and the creation of a code attempted. It is often helpful to work

* Based on a paper presented at the Eighth Annual Meeting of the Canadian Association of Geographers, Edmonton, 1958.

out a number of codes on paper against the material actually in the file before the simplest and most effective code is found. It is doubtful whether a satisfactory code can be developed solely on the basis of theorical and general considerations.

Once the cards have been coded, sorting is a simple procedure. When the sorting needle is inserted into the hole representing the desired symbol and lifted, only the desired cards drop. The number of cards which can be sorted in any one operation is theoretically limited only by the length of the sorter. Practically, however, it amounts to about four inches of cards, a number comparable with that of the electronic sorting systems. If another variable is involved, that is, if one is searching for combinations of factors, the cards extracted can be resorted. Unless many cards are involved, though, it may be more expedient to sort the smaller group by sight.

FRANK A. COOK

GEOGRAPHY IN ONTARIO SCHOOLS

Geography in Ontario schools was non-existent until 1938 when Social Studies - a combination of history, geography and economics - was introduced. Recently, however, geography has gradually become a major subject. It was introduced on an experimental basis in Grade XI and XII in 1952 and was established officially in 1954. In 1955 it was officially established for Grade XIII. Starting with the academic year 1958-59, the Social Studies curriculum will be replaced by courses of studies in which geography and history will be taught as separate subjects in Grade VII to X inclusive.

Thus, as of September 1958, the geography courses at the various grade levels are as follows:—

Grade VII	Ontario and rest of Canada
Grade VIII	U.S.A. and the rest of the Americas
Grade IX	United Kingdom and the rest of the Commonwealth
Grade X	Western Europe and rest of the World
Grade XI	Fundamentals of Geography
Grade XII	Regional Geography
Grade XIII	Geography of Canada

In comparison with the state of Michigan every Ontario high school student will get 12 times the amount of geography taken by the average Michigan student. It is possible, with the options, for the Ontario student to get from 24 to 30 times the amount of geography taken by the average Michigan high school student.

In the U.S.S.R. every boy and girl who completes secondary education has taken six years of geography. In Ontario four years of geography will be required (Grades VII to X), with a total of seven years possible (Grades VII to XIII).

E. G. PLEVA

THE KÖPPEN SYSTEM IN THE CANADIAN FAR WEST

In the area of Canada west of the line McLeod-Edmonton - Fort Simpson - Aklavik, the Köppen classification, in terms of rain-fall regime, shows a Cs climate for the British Columbia Inland Sea Region, a Cf for much of Vancouver Island, all of Queen Charlotte Islands and the British Columbia littoral, three areas of BS and a few scattered areas of Ds. Except for Tundra, it also shows an f for all the remaining portion of the area.

An analysis of the statistics for 190 meteorological stations shows that there are several shortcomings in this. Almost all the stations of interior British Columbia and Yukon, except the few Ds and the Steppe stations, have a definite spring minimum. This feature of the regime is obscured by the Köppen classification. Furthermore there are also Df stations in some of the narrow valleys of the Columbia Mountains with no spring minimum and by a rigid application of the f criteria these are also obscured and the probable close relationship between air masses and terrain is not apparent. Further, the strict use of the f criteria for stations to the east of the Cordillera fails to reveal the significant summer maximum-winter minimum precipitation regime so typical of the continental or microthermal climate.

It is suggested that the further qualifying letter x" should be used with Df to indicate a spring minimum within the Df area and that w be used with Df to indicate the dry winter of that part of the Df area with the continental climate.

There are several advantages to this modification. It retains, unaltered, the Cs, Ds and BS, all with either particular characteristics of regime or significance because of location. The genuine Df of the valleys of the Columbia Mountains stands out clearly in relation to features of the terrain. The spring minimum, common over a very widespread area of the interior of the Cordillera also becomes apparent and finally, for the eastern portion of the area, the continental regime of summer maximum and winter minimum is shown.

B. CORNWALL

54th. ANNUAL MEETING OF THE A.A.G.

The 1958 annual meeting of the Association of American Geographers was held in Santa Monica, California. Dr. W. C. Wonders of the University of Alberta represented the Canadian Association of Geographers. This was the first time that the C.A.G. had designated an official representative to an A.A.G. meeting. It follows the visit of Dr. Chauncy Harris, President of the A.A.C. to the 1958 C.A.G. meetings and is a step towards closer liaison between the two associations.

B. CORNWALL

GEOGRAPHY SECTION OF THE B.A.A.S.

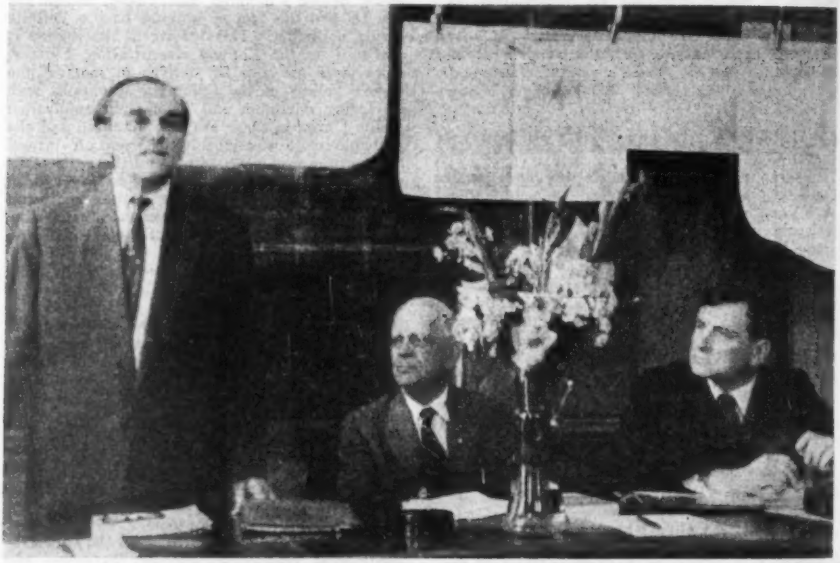
The meetings of Section E (Geography) of the British Association for the Advancement of Science were held in Glasgow in August. Dr. J. D. Chapman of the University of British Columbia represented the Canadian Association of Geographers at the meetings and was elected a member of the section for their duration.

B. CORNWALL

I.G.U. COMMISSION ON NATIONAL ATLASES

Dr. N. L. Nicholson was the first geographer from Canada ever to visit the U.S.S.R. The purpose of his visit was to attend a meeting of the I.G.U. Commission on National Atlases of which he is one of the nine members. While in the Soviet Union he was a guest of the Soviet Academy of Sciences and was afforded opportunities to visit geographers and geographical research institutions in Moscow and Leningrad.

B. BROUILLETTE



The opening session of the Commission on National Atlases. Left to right : Prof. K. A. Salichtchev, Chairman of the Commission; Dr. H. W:Son Ahlmann, President of the International Geographical Union and Academician I.P. Gerasimov, Chairman of the I.G.U. National Committee of the U.S.S.R.

NEW PUBLICATIONS — NOUVELLES PUBLICATIONS

NELSON'S CANADIAN SCHOOL ATLAS. Edited by J. W. WATSON. 92 pp.; maps, photos, gazetteer. Thomas Nelson and Sons (Canada) Ltd., Toronto, 1958. $1.95 8¾ x 12 inches.

THE CANADIAN OXFORD SCHOOL ATLAS. Edited by E. G. PLEVA assorted by SPENCER INCH. 137 pp.; maps, tbls., gazetter. The Oxford University Press, Toronto, 1957. $1.95. 7½ x 10 inches.

The appearance of two new atlasses for use in Canada is a welcome event particularly as one (Nelson's) is designed to assist the teaching of geography at an elementary level while the other (Oxford) is intended for pre-university teaching of geography.

The first 23 pages of Nelson's atlas are hence devoted to a wide variety of subjects including cosmogony, tectonics, geomorphology, map making, climate, types of agriculture, mining and minerals, industrial technology, world exploration, the exploration of Canada, world commercial routes, world population density, and others. These are followed by 9 pages of maps entitled 'Canada and its Resources' which are followed by 48 pages of general maps and relief maps collectively giving world coverage at various scales. The last 12 pages are occupied by a world gazetteer.

The general subjects of the first 23 pages are illustrated with maps, diagrams, photographs and drawings and are accompanied by brief texts. Because of the limitations of space, the coverage of the wide variety of subjects is somewhat superficial. More serious is the fact that some of the information is misleading. The dramatic and artistic presentation of the Jeans theory of the origin of the solar system neglects the fact that Weizsacker's calculations in 1943 restored the Kant-Laplace hypothesis to preference. The theory of continental drift is subscribed to in a colourful diagram although this theory is not today accepted by the majority of geologists. The subject best treated in the section is the exploration of Canada. The four maps on a two-page spread are entitled 'Early Entries by Eastern Gulfs', 'The Prairies and Keewatin', 'Opening up the West and Northwest', and 'The Quest for the Northwest Passage'. In addition to routes of explorers the location of aboriginal tribes, river systems and important passes are shown. The texts are compact and adequately complementary to the maps.

The 9 pages with 26 maps devoted to Canada and its resources cover present population distribution, aboriginal distribution, January and July temperatures, history of settlement and some aspects of the economic geography. The last page of the section, a map of Europe west of Denmak and north of Burgundy entitled 'Origins of our Civilisation' indicates physical features, place names and historical events important in the histories of some of the ethnic groups in the Canadian population. The section as a whole suffers rather badly from crowded layout and austere cartography. Apart from black and white, only two colours, red and blue, are used; they are used as solid colours on the base map or for water features, without binding lines and never in combination. The effects of a single-cour, two-page spread are somewhat forbidding. The maps are not always titled so that the subjects must be determined from the legends, which not being boxed, must be sought for among other entries on the generally crowded pages. As a result the cartography makes it difficult to obtain a picture of Canada and its resources from this series of maps.

The section of General and Relief Maps is introduced by a view of the eastern and western hemispheres. The presentation is artistic, giving the impression of a coloured plaque with the hemispheres in bas-relief. This is followed by a two-pages spread on which the globe (with graticule) is shown from six different points of view. Countries, islands, water features, major cities and air routes are entered. Member countries in a variety of world organizations are identified by colour.

The general maps are pleasing in appearance and easily read, using a yellow base, blue for water, red and black for other items. Relief shading is in brown stipple. The maps show place names, main and secondary railroads, pipelines, a few major roads designated trunk roads, major airports and water features including canals. Relief is shown by shading and a few orographic features are named. Hydro-electric sites, coal, oil, natural gas and iron ore are identified by symbols, while some mineral occurences are identified by name in situ. The general maps collectively cover the world, excluding most of South America and a large part of Australia, which are unaccountably missing. On most of the maps of areas outside of North America there is an inset of part of the Lower Great Lakes region at the scale of the main map; this device is of great assistance in appreciating map scales and space relationships.

There is a relief map of each of the continents, excluding Antarctica, and Canada is represented separately as well as with North America. Hypsometric layer colours and spot heights are used to show elevations, with the colours grading into each other rather than having distinct boundaries. Relief is shown by shading superimposed on the layer colours. Relief shading has perhaps been overdone in places, as in the case of the recessional moraines around the Great Lakes which do not appear very differently from complex mountain ranges. Ice caps are shown but are not identified in the legend. Bathymery is not shown. A solid dark blue is used for water, while colours used for land elevations grade from green to red. In addition to elevation and relief, major railways and cities appear on the maps. Tropical and temperate-boreal forests are represented by green tree symbols, desert by red stipple, tundra by red symbols. Major orographic features and some physiographic regions are named. The solid blue for water and the red used for desert, tundra and high elevation give the maps a somewhat lurid appearance. Dot maps inset on the relief maps show population

distribution for continents and in the case of South America the inset map also shows mineral occurrences.

The concept of physiographic regions has been by and large neglected. On the relief maps some physiographic regions are named but there is little consistency. For example, on the relief map of North America the Interior Lowlands (shown as being west of the Mississippi), the Ozark Plateau, the Colorado Plateau, the Laurentian Shield (*sic*) and the Great Basin are named, but the Great Plains, the Coastal Plain, and the Mexican Plateau are not.

The gazetteer contains approximately 7800 entries, both place and feature names. Indexed names are located on the map by reference to letters and numbers applied to the geodetic graticule. The system works well in low latitudes but in high latitudes where convergence of the meridians is marked and the parallels approach ellipticity there are problems in the placement of the letters and numbers which make for difficulties in locating the indexed names.

Although *The Canadian Oxford School Atlas* is designed to assist in the pre-university teaching of geography, its organization is sufficiently flexible that it could be used both at elementary and advanced levels. It is planned so as to provide information for all areas of the world on population, relief and elevation, bathymetry, geology, vegetation, climate, soils, agriculture, fuel resources, minerals, transportation, political divisions and place and feature names. The work is so organized in terms of different scales and the the use of insets that the detail with which the above subjects are dealt with is varied from area to area in accordance with the interests of geography in Canada.

The first 29 pages are devoted exclusively to Canada, the following 74 pages collectively give world coverage while the remaining pages include a chronicle of explorers, a table of statistical data for countries of the world, a gazetteer of Canada and a gazetteer of the world. The last page is a table of topical data on countries of the Middle East. The inside of the back cover is a detailed map of the Middle East.

Excepting the section on Canada, continents are the basic mapping unit for most of the topics listed above. The master scheme of the atlas may be illustrated by the treatment of North and South America. The first plate of the Americas, occuping a double page, is a relief and hypsometric map entitled 'Physical', with an inset of a simplified geological map entitled 'Build'. Elevations on the main map are shown by spot heights and hypsometric layer colours, relief by shading superimposed on the layer colours. The second plate, entitled 'Vegetation', at the same scale as the first, shows 13 classifications of vegetation (plus ice-caps), which are keyed to the legend by colour and numbers. There is a small inset showing annual rainfall, and distributed around the main map are graphs of climatic regimes (precipitation and temperature) for a selection of stations which are marked on the map. The third map of the Americas, on the same scale as the preceding two, is entitled 'Population and Communications'. It shows population density by graded tints, railroads, shipping routes with comparative traffic volume by width of line, and urban centres (unnamed) according to two population categories — 100,000 to 1,000,000 and over 1,000,000. The inset map entitled 'Power' shows coal, oil, uranium and hydro-electric sites. The remainder of the section on the Americas is taken up by general maps, a preference in scales being given to areas of greatest interest to Canada. The larger scale general maps are usually hypsometric, using layer colours and spot heights, while the smaller scale general maps are hypsometric and also have relief shading superimposed on the layer colours. The scheme of treatment of the Americas is typical, with some variation, of the treatment of the other continents. The map section of the atlas is concluded by a series of 17 maps in which the subjects dealt with throughout are treated synoptically for the whole world.

The opening section of the atlas, devoted exclusively to Canada, in general follows the master scheme of the whole with the difference that larger scales are used and there is consequently greater detail. Subjects that appear as insets in the rest of the atlas are given full page coverage in the section on Canada. In addition the maps of Canada have fairly extensive notes which considerably supplement the data of the maps and provide incidental information such as the derivation of the names of provinces and details of the St. Lawrence Seaway. The largest scale used for the general maps of Canada is 1 : 500,000, the smallest 1 : 8,000,000. While continents are the basic mapping unit, the importance of the oceans has not been overlooked. There are maps of the Atlantic, Pacific and Indian Oceans which show among other things, currents and bathymetry, the latter by layer tints and soundings. Bathymetric data is also recorded on many other maps throughout the atlas. The gazetteer of Canada contains approximately 500 entries and the gazetteer of the world approximately 6900. Location is given according to latitude and longitude.

In general the cartography is excellent, although in a few cases relief shading on some of the general maps is perhaps too strong and diverts attention from other features. This of course pays tribute to the effectiveness of relief representation, but the general maps which have hypsometric layer colours only are easier to read than those that also have relief shading. The concept of physiographic regions is neglected in this work so far as maps specifically devoted to the subject are concerned but the present selection of material is sufficiently judicious that physiographic maps could not be considered as replacements but would be useful additions.

The excellent planning as represented by the consistent build-up of information from map to map and section to section, the imagination as represented by such insets as the one of the Holy Land in biblical times, and the quality of the cartography, highly recommend this atlas

not only for teaching but also as a source of general geographic information.

G. FREMLIN

GLACIAL MAP OF CANADA. Publiée par Geological Association of Canada, 1958. $2.00. 48 x 59½ pouces; échelle 1 : 3,801,600. (On peut obtenir cette carte de M. Roliff, Imperial Oil Co., 111 St. Clair Ave. W., Toronto 7, Ontario).

L'Association Géologique du Canada vient d'avoir la très heureuse initiative de publier une carte de synthèse de phénomènes glaciaires au Canada. Il s'agit indubitablement d'une œuvre d'envergure puisque scientifiquement, elle couvre un ensemble de phénomènes très complexes, et géographiquement, un demi-continent dont la surface équivaut à celle de l'Europe. Les symboles, les couleurs choisies, la présentation de toutes les données font de cette carte un modèle du genre: même dans les région où plusieurs phénomènes se superposent, on a toujours une impression de clarté parfaite.

Parmi les phénomènes les plus complètement et minutieusement représentés, il convient de signaler les réseaux des eskers et des drumlins dont la représentation à cette échelle continentale est d'une extraordinaire précision. Il faut souligner cette divergence en arc de cercle presque parfait, à partir du centre de dispersion du Nord du Québec. L'extension des anciens lacs pléistocènes a été précisée avec beaucoup de soin, de même ques les limites maximums de la transgression marine post-glaciaire pour laquelle les altitudes régionales ont été indiquées. La carte donne aussi la limite précise des glaciers actuels pour tout le N. de l'Amérique, sauf l'Alaska.

D'autres points appellent cependant des réserves et certaines critiques que nous voulons être essentiellement constructives.

La première critique s'adressera à la présentation exclusive des altitudes en pieds; il aurait été éminemment souhaitable par déférence pour les géologues et les glaciologues d'Europe et des autres continents où le système métrique est employé, que toutes les mesures de cette carte fussent imprimées dans les deux systèmes. Relativement aux cotes d'altitude, il est permis de regretter que l'on ait négligé de porter l'altitude des principaux lacs de la carte, et celle de leur extension maximum, de même que de leurs principales terrasses.

Plusieurs des îles de l'archipel de l'Océan Arctique sont classées comme non glaciées au Pléistocène, cela est possible, mais il est permis de penser que pour plusieurs points, l'hypothèse contraire demeure vraisemblable : en effet l'absence des stries, de drumlins et d'eskers n'est pas une preuve concluante d'absence de glaciation: il s'agit ici de régions pour la plupart à structure horizontale caractérisées par des roches sédimentaires, tendres, donc très gélivées, principalement des grès, des calcaires et des dolomies, roches dans lesquelles il est illusoire de s'attendre de trouver des stries bien conservées; il es d'autre part très possible que des causes particulières aient empêché la formation de drumlins et d'eskers, à l'exemple d'ailleurs des régions notoirement glaciées où ces formes manquent. D'autre part, l'absence d'indices morainiques ne peut pas être invoqué contre l'hypothèse de la présence de glaciations dans d'immenses régions présentant toutes, ou à peu près, le même cortège lithologique.

Il faut signaler de regrettables et d'incompréhensibles lacunes dans le bassin du fleuve St-Laurent qui en principe aurait dû être une des régions les mieux travaillées :

Tout d'abord, la délimitation des régions recouvertes par la Mer Champlain est non seulement incomplète mais très imprécise en plusieurs endroits: en aval de l'Ile d'Orléans et jusqu'à Tadoussac les dépôts Champlain apparaissent sur la carte avec une largeur de 30 à 40 km., alors qu'en réalité, ceux-ci sont pratiquement inexistants, excepté quelques terrasses à l'embouchure de certaines vallées et quelques placages larges de 1 ou 2 km au plus, le long des rives du St-Laurent. Par contre, de Tadoussac à Baie-Comeau la carte ne porte pas trace de terrasses, alors que des Grandes Bergeronnes à 15 km au N-E de Tadoussac et jusqu'à Baie-Comeau, à une centaine de km plus au N-E, il y a un et parfois deux niveaux de terrasses très nets de 2 à 10 km de large, formant une bande continue de dépôts meubles entre les Laurentides et le St-Laurent. A quoi tiennent ces omissions alors que paradoxalement sur les rives de la Baie d'Hudson des séries de 6 à 7 terrasses parallèles sont portées avec une extraordinaire minutie ?

Une des plus graves lacunes de cette carte concerne, pour les régions du St-Laurent entre autres, les dépôts fluvio-glaciaires qui semblent avoir été confondus en plusieurs endroits avec ceux de la Mer Champlain, probablement en raison du fait qu'il n'y a pas de différence nette de niveau entre les premiers et les seconds: il semble que la distinction fondamentale entre la nature des dépôts fluvio-glacaires (essentiellement sableux) et celle des dépôts de la Mer Champlain (à prédominance argileuse) ait échappé aux auteurs. En fait, le symbole affecté aux produits de délavage fluvio-glaciaire n'apparaît qu'à quelques endroits sur cette immense carte: cela est d'autant plus inconcevable que l'embouchure et les vallées de toutes les rivières parcourues par des routes et par des voies ferrées entre le Saguenay et l'Outaouais montrent d'innombrables coupes de produits fluvio-glaciaires caractériés, d'une puissance de 20 à 25 m; cela est d'autant plus regrettable que ces épandages fluvio-glaciaires remontent souvent très loin dans les vallées, la plupart du temps de 50 à 75 km à l'intérieur du Plateau Laurentien et à 150 km au moins pour ce qui est de la Rivière St-Maurice.

Sur la rive sud du St-Laurent des zones de dépôts fluvio-glaciaires très importantes ont été complètement passées sous silence, nous citerons pour mémoire les épandages de la vallée de la Matapédia, ceux du Lac Témiscouata, et ceux

de la vallée de la Chaudière. L'on reste littéralement interdit en constatant qu'il n'y a pas une seule mention de dépôts fluvio-glaciaires pour tout l'ensemble du bassin de Mackenzie, où pourtant ils forment l'essentiel des sédiments de cette immense région.

La méconnaissance des caractéristiques fondamentales des dépôts glaciaires et fluvio-glaciaires surtout, est peut-être la cause que l'observation et l'interprétation correcte de ceux-ci, de même que leur importance capitale dans le cadre d'une carte de synthèse des phénomènes glaciaires aient presque totalement échappé à l'attention des chercheurs de terrain et à celle des auteurs de la carte.

Il appert en outre, de ce qui précède, que cette carte a été préparée à partir de l'étude intelligente et détaillée des photographies aériennes. Pour toutes les régions où les études régionales sont extrêmement rares et dispersées, on a fait un emploi très intelligent et efficace de la photographie aérienne, dont l'étude détaillée, a incontestablement été des plus rentable pour la cartographie de tous les phénomènes et spécialement de ceux situés dans les zones de taïga, de toundra et de roche nue. Et c'est peut-être ce qui explique que les régions nordiques paraissent pour certains phénomènes mieux étudiés que ceux du Sud. Les sources bibliographiques indiquées sont nombreuses, consistant en des rapports géologiques surtout mais ceux-ci sont malheureusement d'une insuffisance avérée en ce qui concerne la Géologie du Quaternaire.

Est-il permis de souhaiter en conclusion, qu'une édition ultérieure de la carte du Glaciaire au Canada aille plus en profondeur en fournissant d'innombrables données numériques sur la hauteur, la largeur, la longueur des eskers et des drumlins des diverses régions étudiées, des précisions sur l'extension et l'épaisseur des moraines de fond (dont aucune mention n'a été faite sur la carte) et des moraines frontales, sur l'extension et sur la puissance des épandages fluvio-glaciaires, au moins pour les régions facilement accessibles à l'observation. Peut-on suggérer que se répande l'emploi de méthodes aussi utiles, simples et accessibles que les comptages de nature pétrographique qeu la granulométrie et la morphimétrie des galets et des blocs de même que la morphoscopie des sables.

Les critiques qui précèdent, formulées dans un esprit constructif ne doivent pas minimiser, aux yeux de quiconque, le gigantesque travail et la remarquable contribution à la connaissance du Pléistocène, de ses dépôts et de ses formes tant à l'échelle de l'Amérique qu'à celle même du Globe, que constitue la publication de cette carte du Glaciaire dont on peut dire qu'elle est admirable et très neuve.

MICHEL BROCHU

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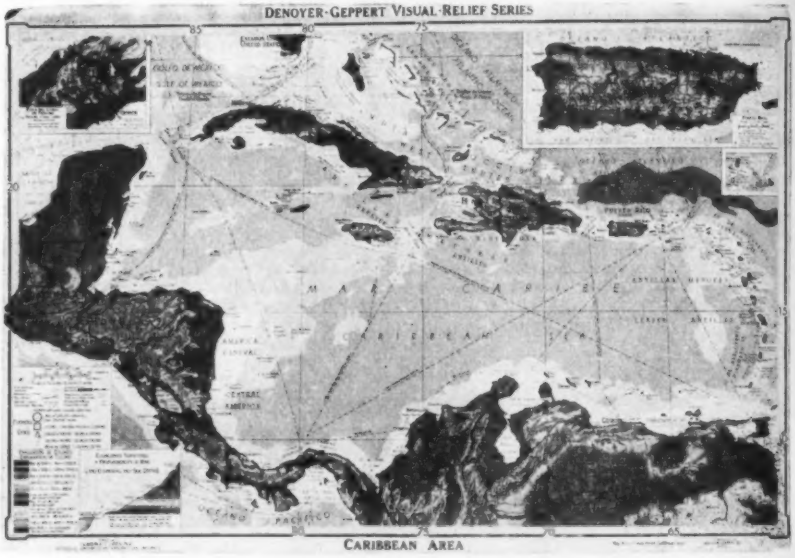

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